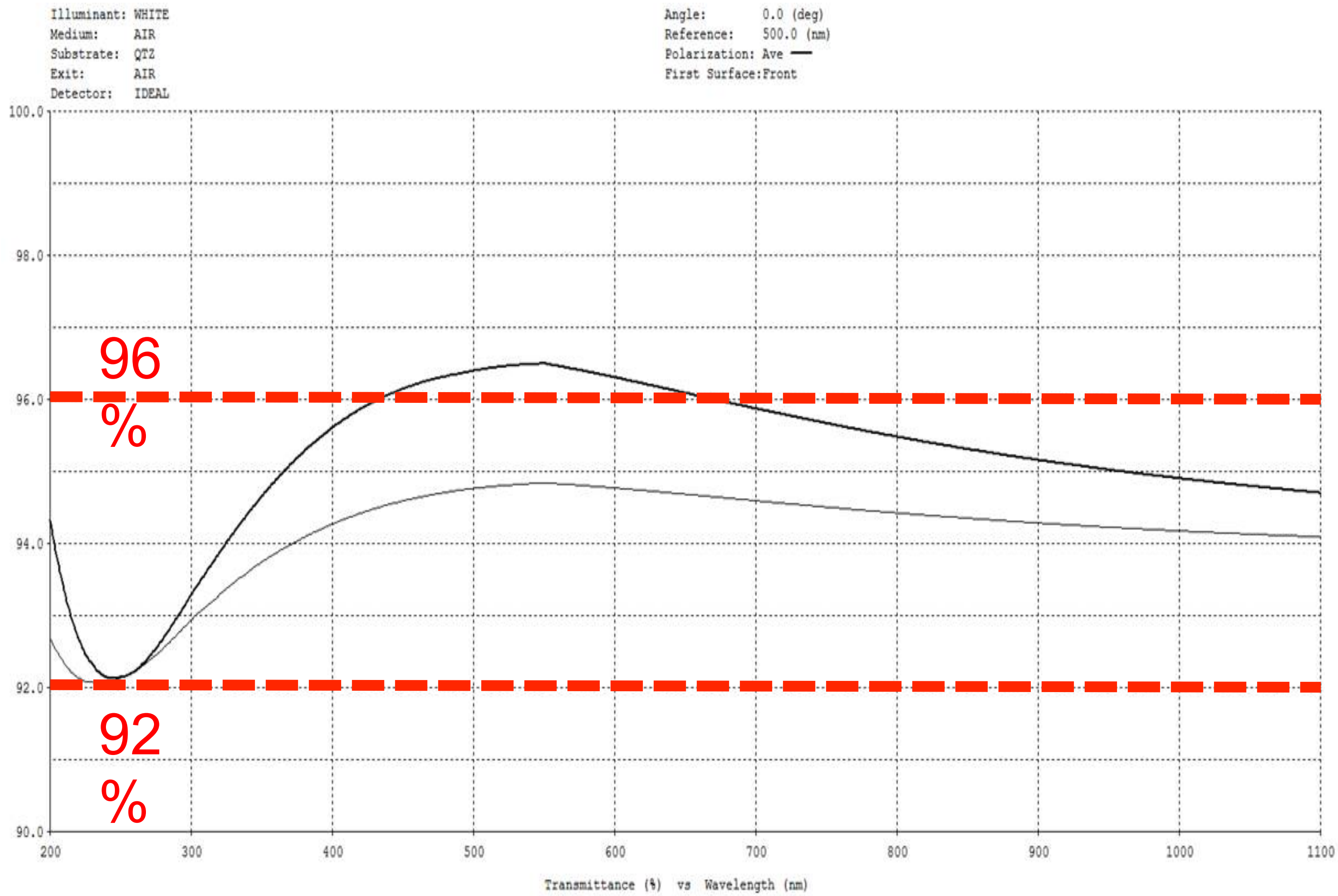
Initial AT Camera Characterization

David Kirk Gilmore

DESC-PCWG
LPNHE, Oct. 3, 2018

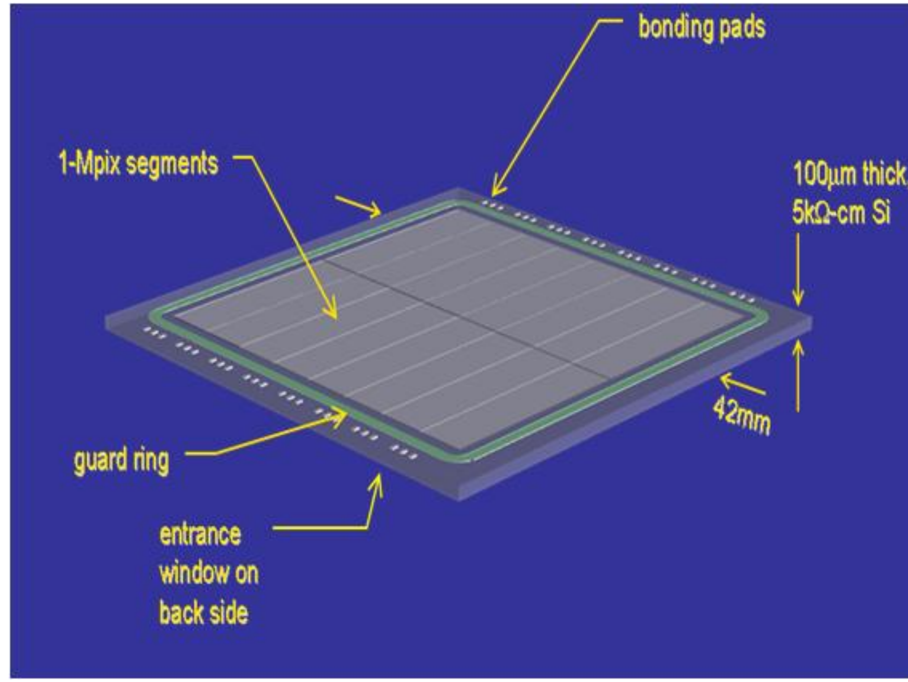
MgF2 BBAR Coating (ios Optics)

The coating bandwidth is very broad and we will not be able to meet your required specification (>96% T). What we can do is to AR coat both sides with Single Layer MgF2.

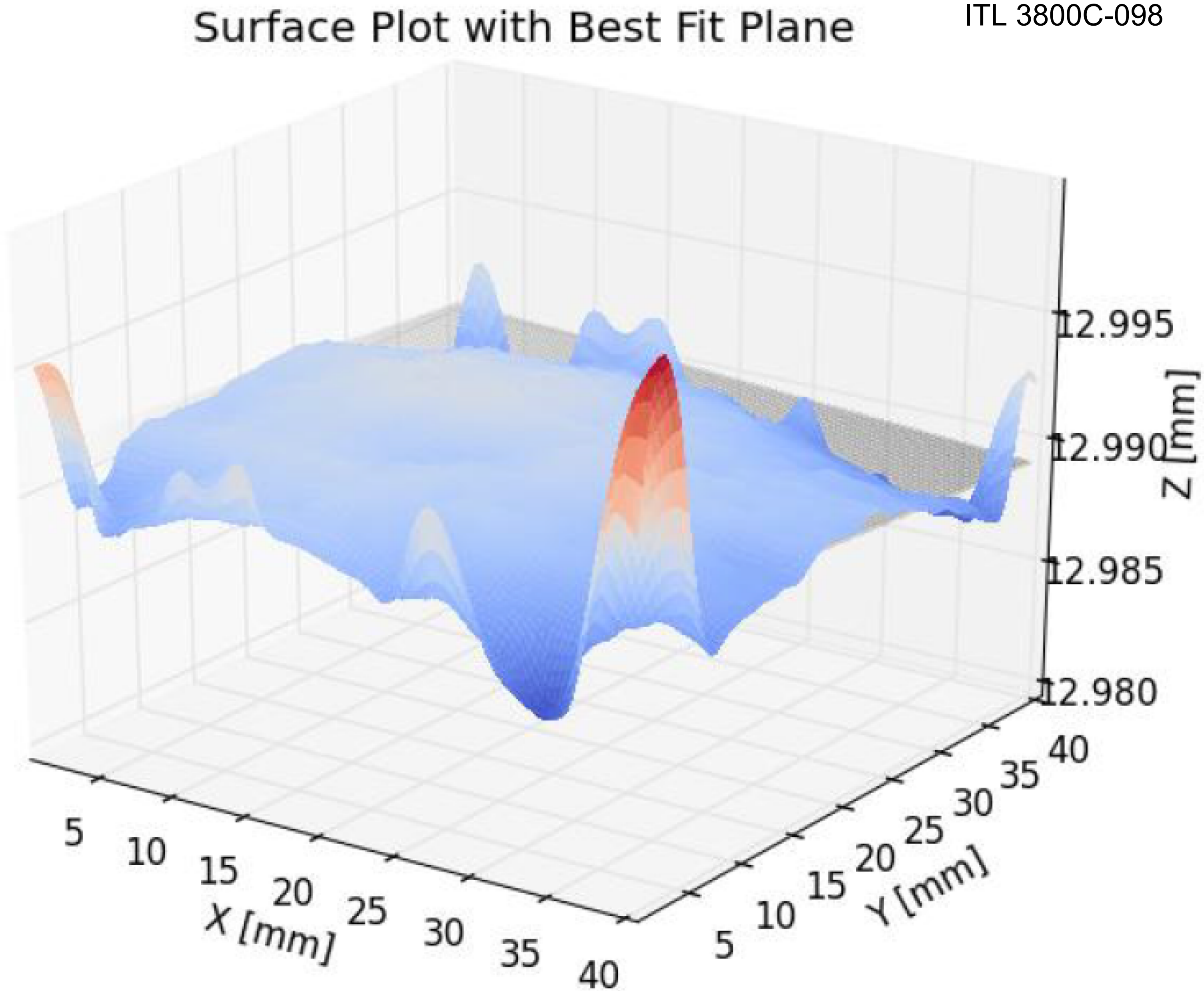


An LSST science sensor will be used as the ATS sensor

- 100μm-thick, high resistivity silicon CCDs, fully-depleted with transparent conductive window and AR coating
    - *for broadband QE and small PSF*
- 4K x 4K format
    - *4 die sites/6” wafer*
- 16-fold parallel output
    - *for low noise readout at 2s frame read time*
- 10μm pixels
    - *for optimum sampling at LSST plate scale*
- Buttable, thermally-matched packaging
    - *>92% fill factor*
- Flatness and coplanarity to bring image surface within ±0.009mm from baseplate
    - *for use in fast f/1.2 beam*
      for the ATSSROS f/18 beam this is not critical
- Mechanical mounting and alignment features and electrical interface specified



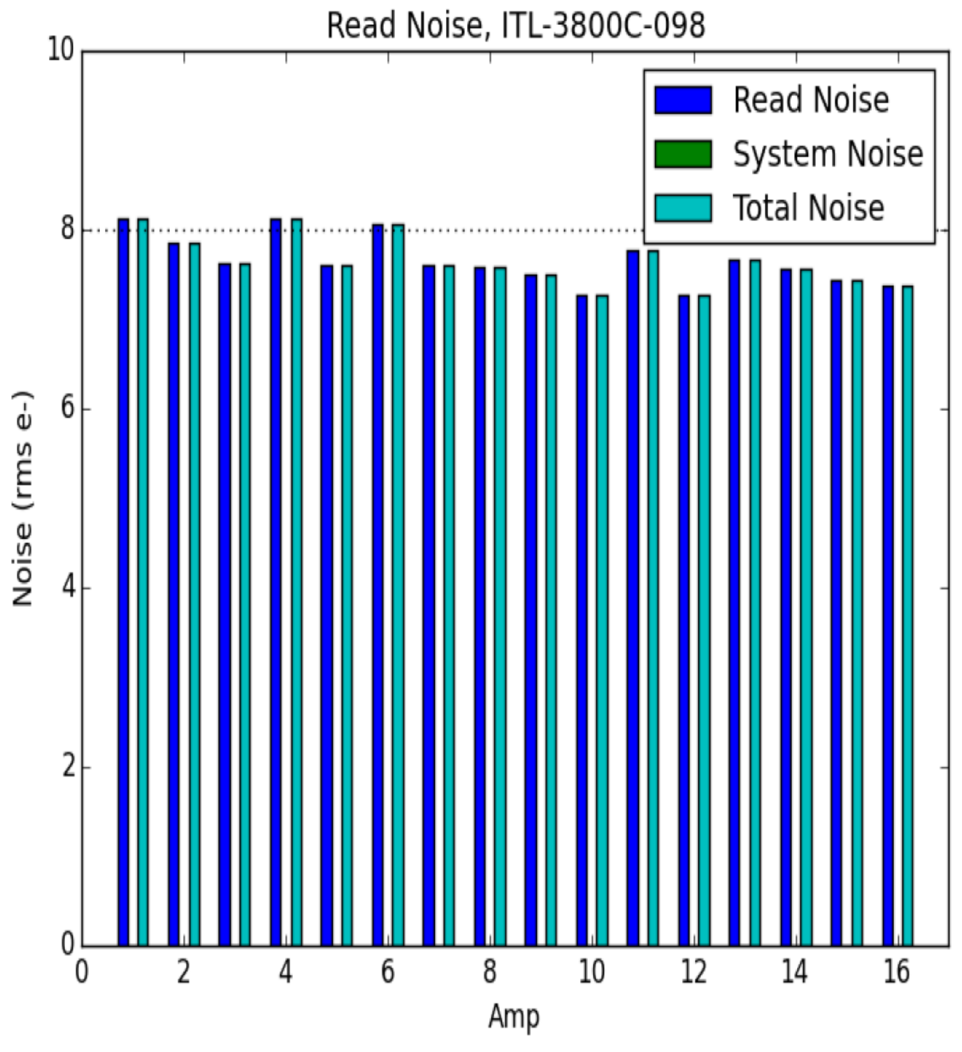
ITL 3800C-098



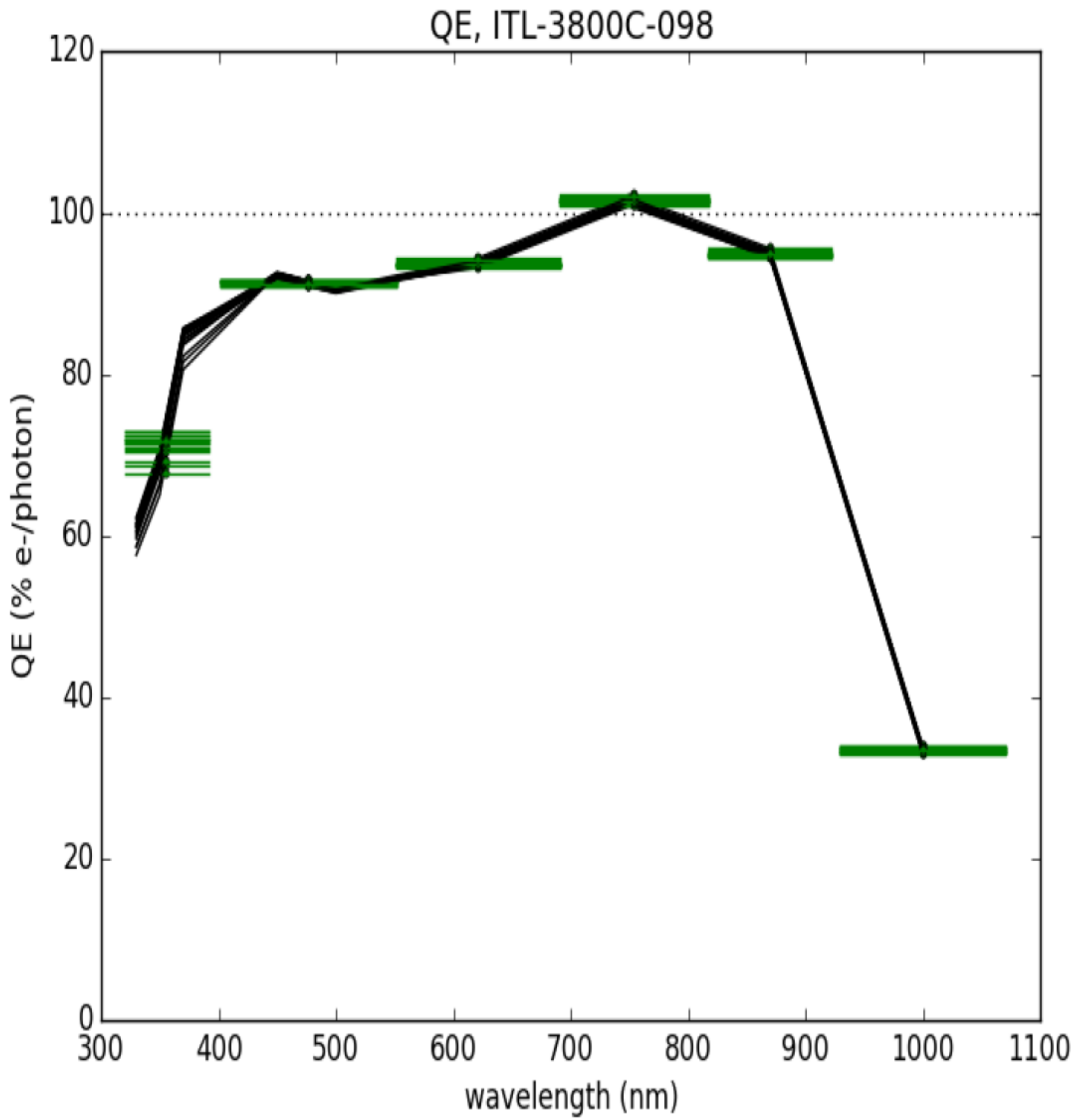
Surface Plot.

CCD – ITL-098: Read Noise

Amplifiers 1,4, and 6 fail read noise



CCD – ITL-098: System QE



CCD – ITL-098: High Flux CTE

6.1 High Flux

Serial CTEs that fail, fail by between 1.97E-6 and 0.25E-6.

Amp	Serial CTE	Parallel CTE
1	$1 - 5.38 \times 10^{-6} \pm 1.70 \times 10^{-7}$	$1 - 1.82 \times 10^{-7} \pm 7.77 \times 10^{-8}$
2	$1 - 5.36 \times 10^{-6} \pm 1.54 \times 10^{-7}$	$1 - 2.57 \times 10^{-7} \pm 7.85 \times 10^{-8}$
3	$1 - 5.25 \times 10^{-6} \pm 1.57 \times 10^{-7}$	$1 - 2.94 \times 10^{-7} \pm 7.97 \times 10^{-8}$
4	$1 - 6.97 \times 10^{-6} \pm 1.50 \times 10^{-7}$	$1 - 2.91 \times 10^{-7} \pm 7.56 \times 10^{-8}$
5	$1 - 4.65 \times 10^{-6} \pm 1.49 \times 10^{-7}$	$1 - 2.82 \times 10^{-7} \pm 7.56 \times 10^{-8}$
6	$1 - 5.93 \times 10^{-6} \pm 1.57 \times 10^{-7}$	$1 - 2.73 \times 10^{-7} \pm 7.98 \times 10^{-8}$
7	$1 - 4.27 \times 10^{-6} \pm 1.49 \times 10^{-7}$	$1 - 2.71 \times 10^{-7} \pm 7.52 \times 10^{-8}$
8	$1 - 2.63 \times 10^{-6} \pm 1.57 \times 10^{-7}$	$1 - 2.32 \times 10^{-7} \pm 7.92 \times 10^{-8}$
9	$1 - 1.33 \times 10^{-6} \pm 1.50 \times 10^{-7}$	$1 - 1.71 \times 10^{-7} \pm 7.53 \times 10^{-8}$
10	$1 - 3.20 \times 10^{-6} \pm 1.50 \times 10^{-7}$	$1 - 2.08 \times 10^{-7} \pm 7.52 \times 10^{-8}$
11	$1 - 4.77 \times 10^{-6} \pm 1.54 \times 10^{-7}$	$1 - 2.11 \times 10^{-7} \pm 7.69 \times 10^{-8}$
12	$1 - 4.07 \times 10^{-6} \pm 1.57 \times 10^{-7}$	$1 - 9.92 \times 10^{-8} \pm 7.83 \times 10^{-8}$
13	$1 - 5.27 \times 10^{-6} \pm 1.56 \times 10^{-7}$	$1 - 2.18 \times 10^{-7} \pm 7.78 \times 10^{-8}$
14	$1 - 3.81 \times 10^{-6} \pm 1.52 \times 10^{-7}$	$1 - 2.54 \times 10^{-7} \pm 7.58 \times 10^{-8}$
15	$1 - 3.75 \times 10^{-6} \pm 1.51 \times 10^{-7}$	$1 - 1.04 \times 10^{-7} \pm 7.54 \times 10^{-8}$
16	$1 - 3.47 \times 10^{-6} \pm 1.66 \times 10^{-7}$	$1 - 1.44 \times 10^{-7} \pm 7.38 \times 10^{-8}$

No Parallel CTE failures

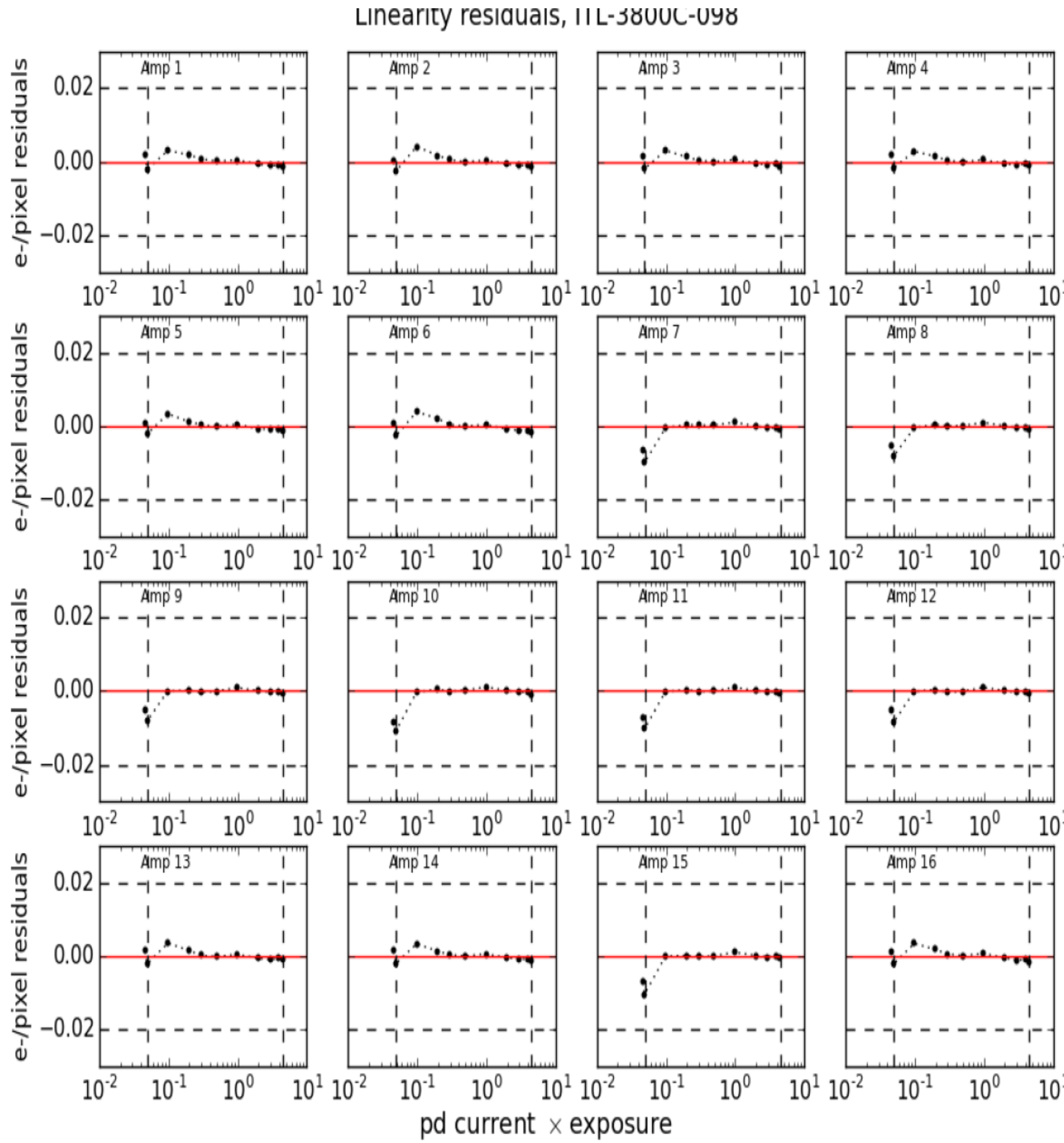
CCD – ITL-098: Low Flux CTE

6.2 Low Flux

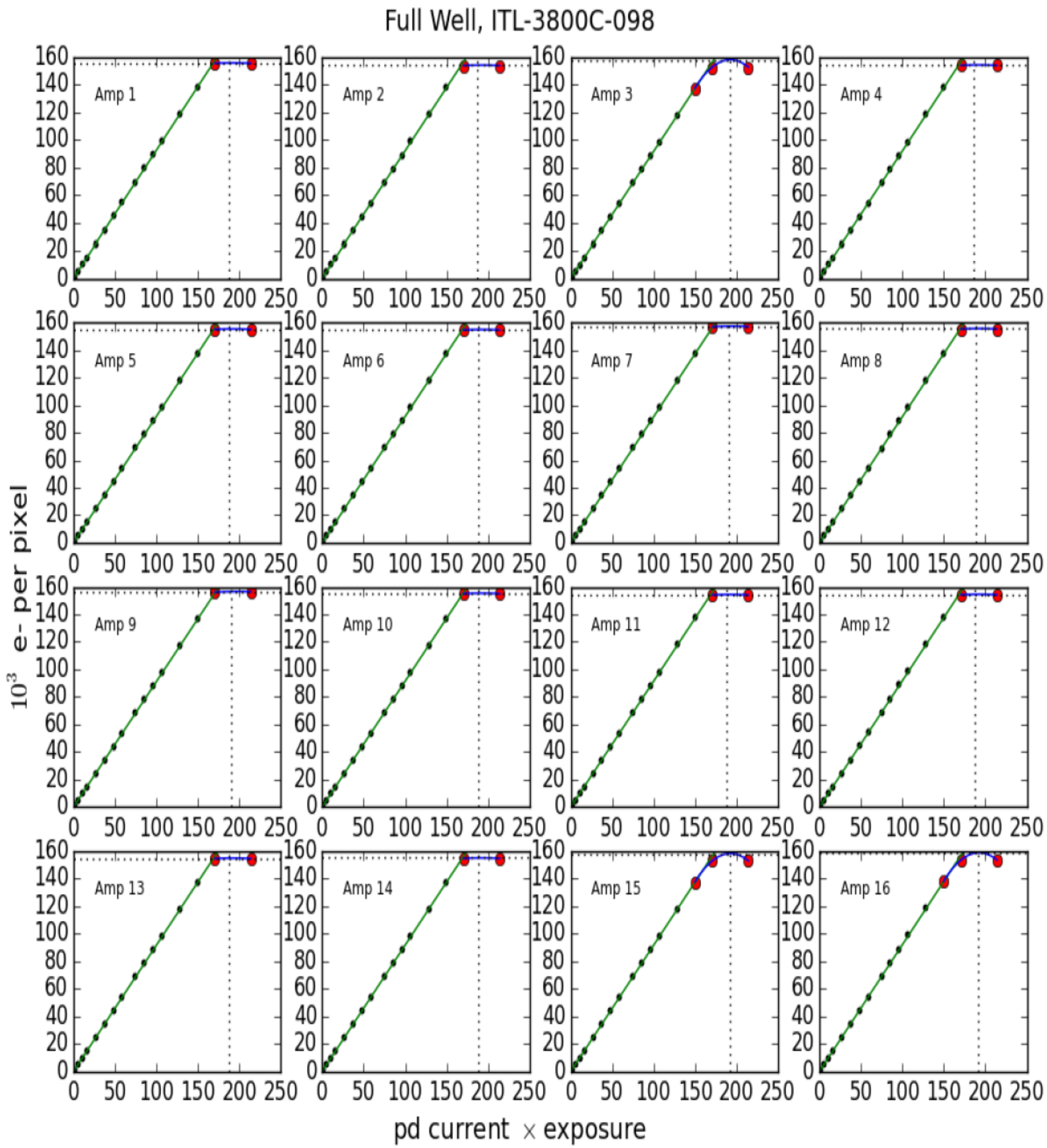
More Serial CTEs fail at low flux than at high flux, but AuxTel targets should be bright, with high SNR

Amp	Serial CTE	Parallel CTE
1	$1 + 2.68 \times 10^{-6} \pm 8.51 \times 10^{-6}$	$1 - 5.99 \times 10^{-6} \pm 3.81 \times 10^{-6}$
2	$1 - 1.37 \times 10^{-5} \pm 7.63 \times 10^{-6}$	$1 - 9.68 \times 10^{-6} \pm 3.77 \times 10^{-6}$
3	$1 - 7.78 \times 10^{-6} \pm 7.82 \times 10^{-6}$	$1 - 1.09 \times 10^{-5} \pm 3.82 \times 10^{-6}$
4	$1 + 1.02 \times 10^{-5} \pm 7.48 \times 10^{-6}$	$1 - 1.01 \times 10^{-5} \pm 3.65 \times 10^{-6}$
5	$1 - 3.09 \times 10^{-6} \pm 7.43 \times 10^{-6}$	$1 - 1.07 \times 10^{-5} \pm 3.64 \times 10^{-6}$
6	$1 - 1.58 \times 10^{-5} \pm 7.79 \times 10^{-6}$	$1 - 1.05 \times 10^{-5} \pm 3.82 \times 10^{-6}$
7	$1 + 2.84 \times 10^{-6} \pm 7.44 \times 10^{-6}$	$1 - 1.05 \times 10^{-5} \pm 3.63 \times 10^{-6}$
8	$1 - 7.72 \times 10^{-6} \pm 7.77 \times 10^{-6}$	$1 - 1.06 \times 10^{-5} \pm 3.80 \times 10^{-6}$
9	$1 - 1.40 \times 10^{-5} \pm 7.45 \times 10^{-6}$	$1 - 8.02 \times 10^{-6} \pm 3.64 \times 10^{-6}$
10	$1 - 3.12 \times 10^{-6} \pm 7.47 \times 10^{-6}$	$1 - 8.02 \times 10^{-6} \pm 3.63 \times 10^{-6}$
11	$1 - 8.57 \times 10^{-6} \pm 7.62 \times 10^{-6}$	$1 - 8.06 \times 10^{-6} \pm 3.70 \times 10^{-6}$
12	$1 - 1.89 \times 10^{-7} \pm 7.80 \times 10^{-6}$	$1 - 3.82 \times 10^{-6} \pm 3.81 \times 10^{-6}$
13	$1 - 3.30 \times 10^{-6} \pm 7.75 \times 10^{-6}$	$1 - 7.52 \times 10^{-6} \pm 3.76 \times 10^{-6}$
14	$1 - 2.99 \times 10^{-5} \pm 7.50 \times 10^{-6}$	$1 - 9.90 \times 10^{-6} \pm 3.64 \times 10^{-6}$
15	$1 - 1.04 \times 10^{-5} \pm 7.50 \times 10^{-6}$	$1 - 2.52 \times 10^{-6} \pm 3.66 \times 10^{-6}$
16	$1 - 7.19 \times 10^{-6} \pm 8.27 \times 10^{-6}$	$1 - 4.73 \times 10^{-6} \pm 3.58 \times 10^{-6}$

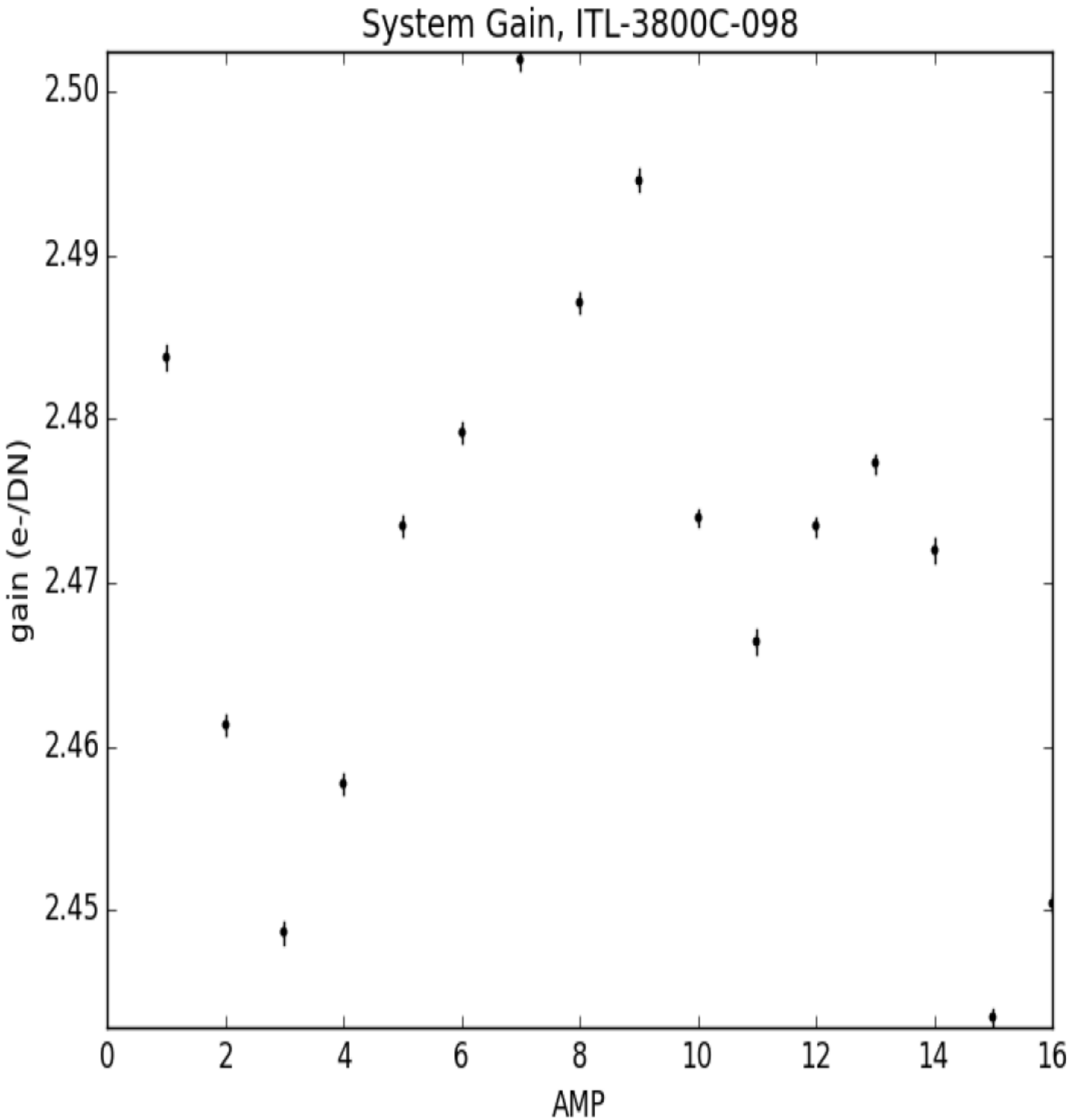
CCD – ITL-098: Linearity



CCD – ITL-098: Full Well

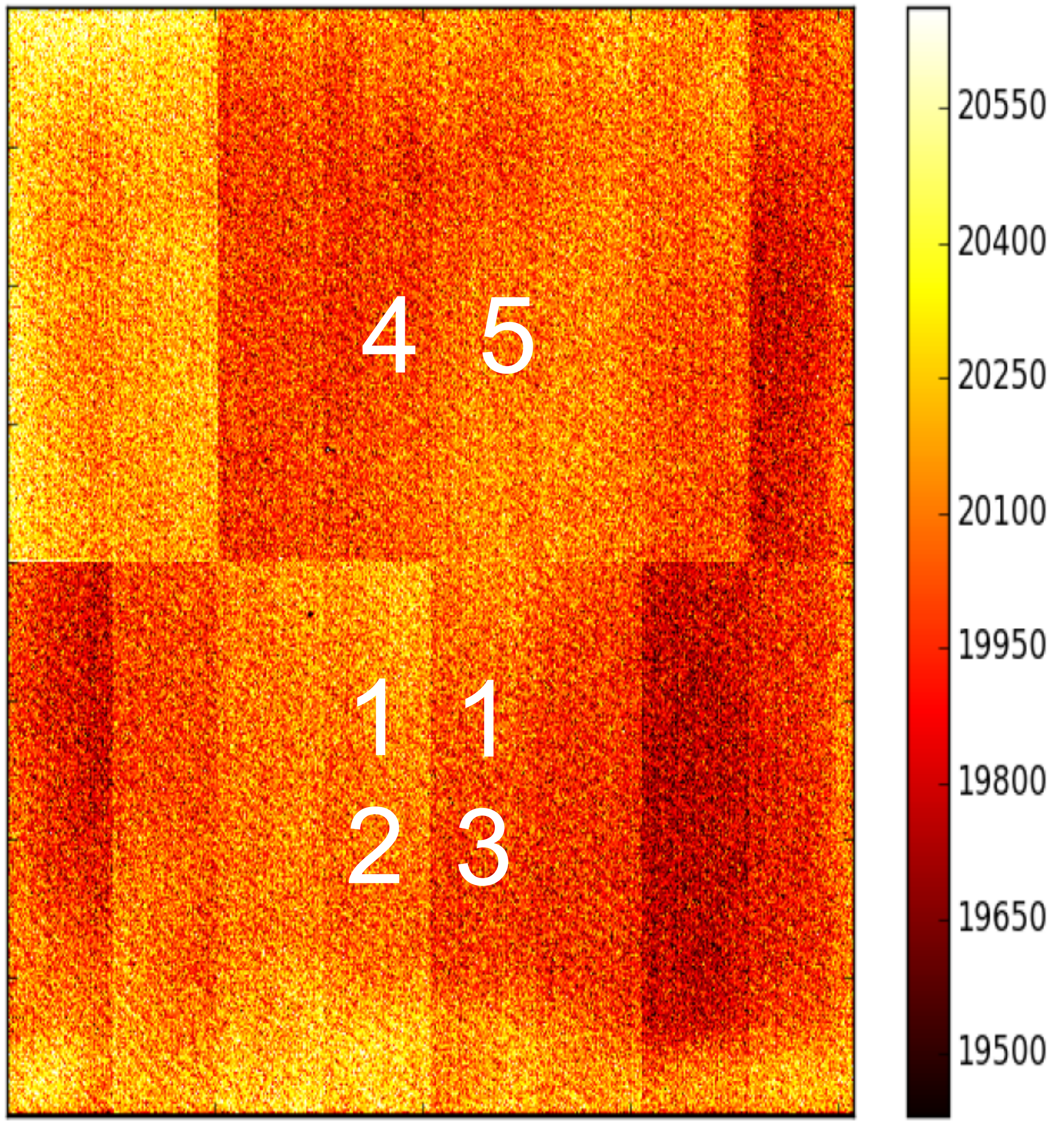


CCD – ITL-098: Gain

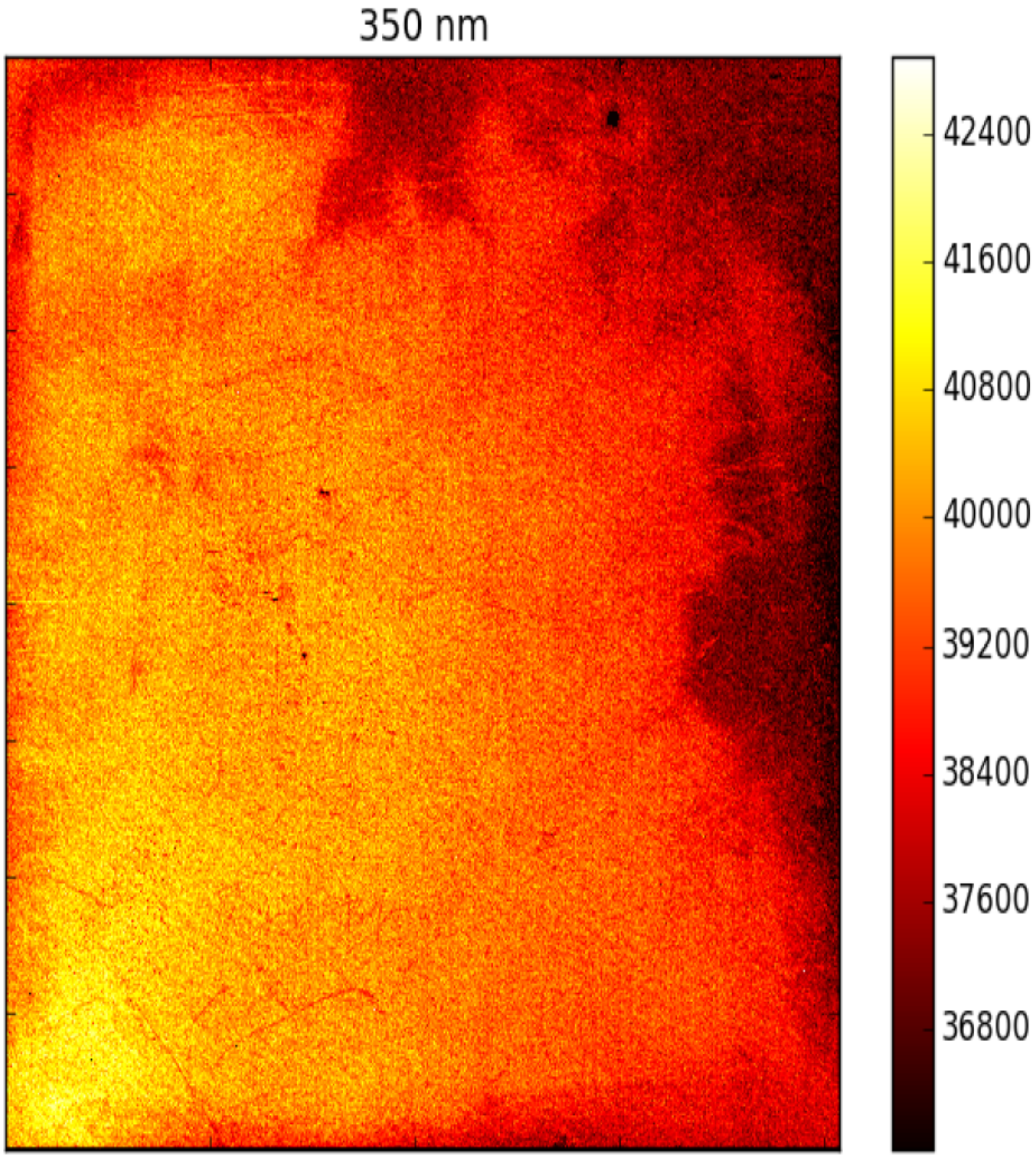


CCD – ITL-098: Superflat

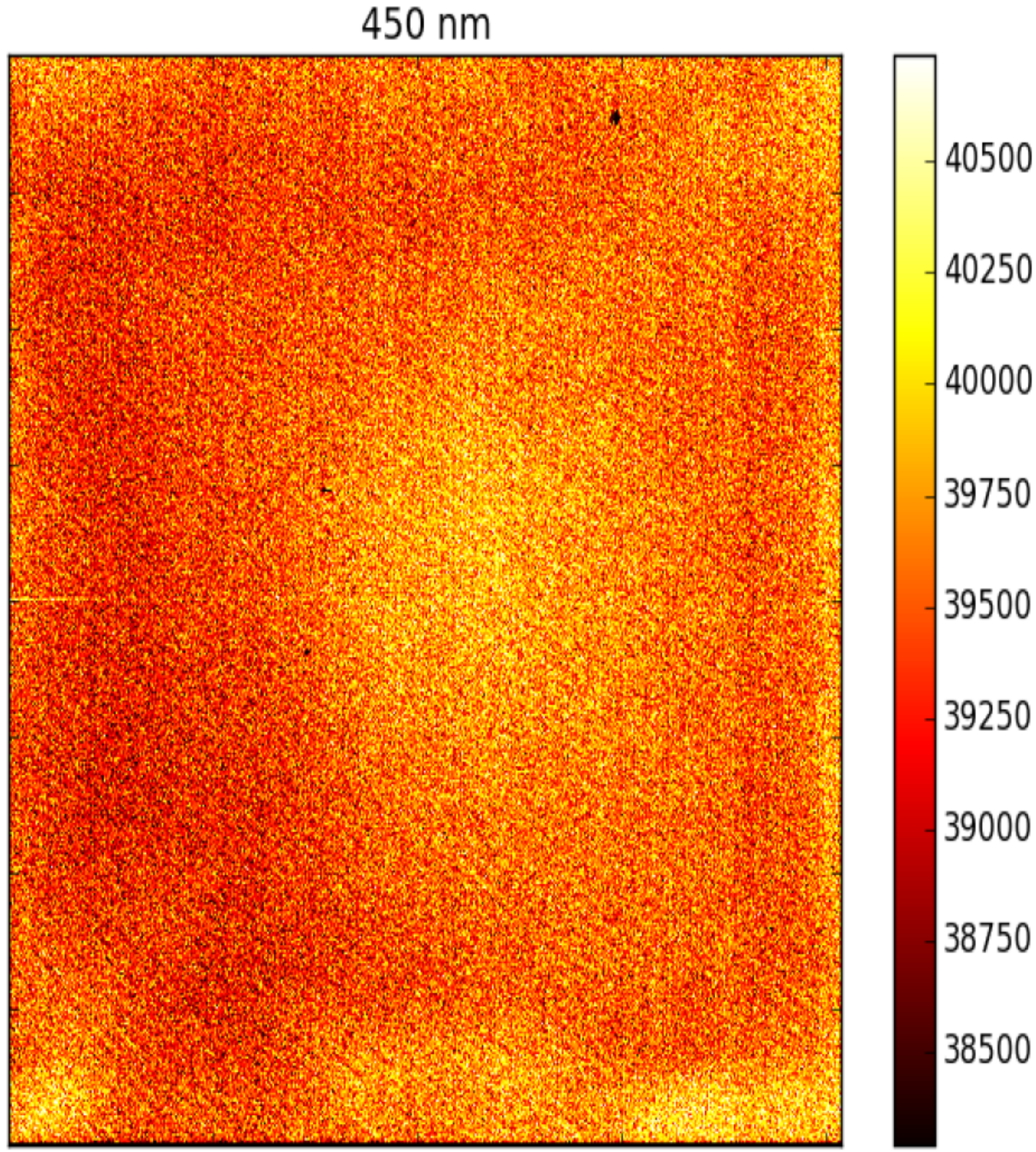
Ideal imaging area lies on amplifiers 4,5,12, and 13.



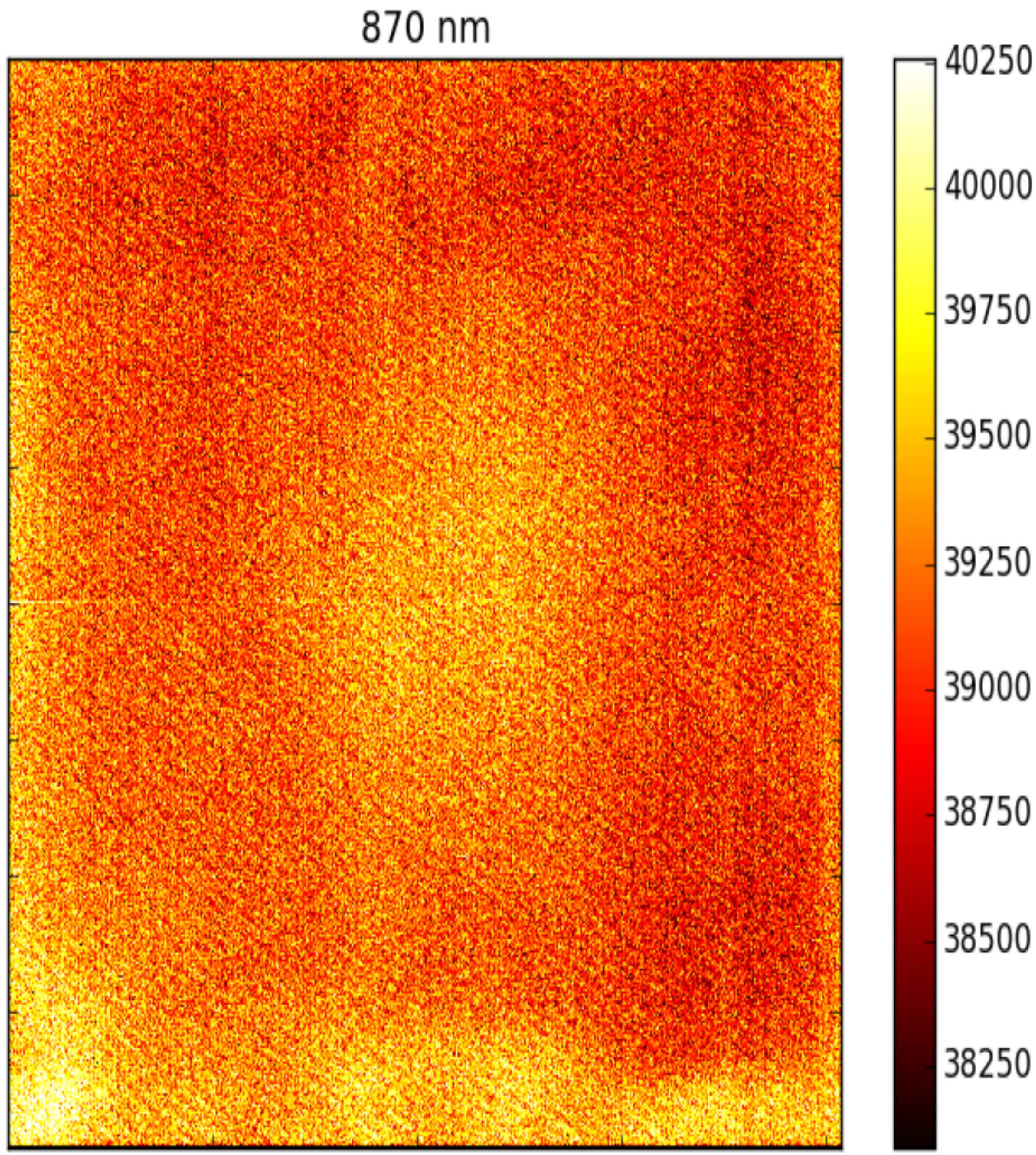
CCD – ITL-098: 350nm Response



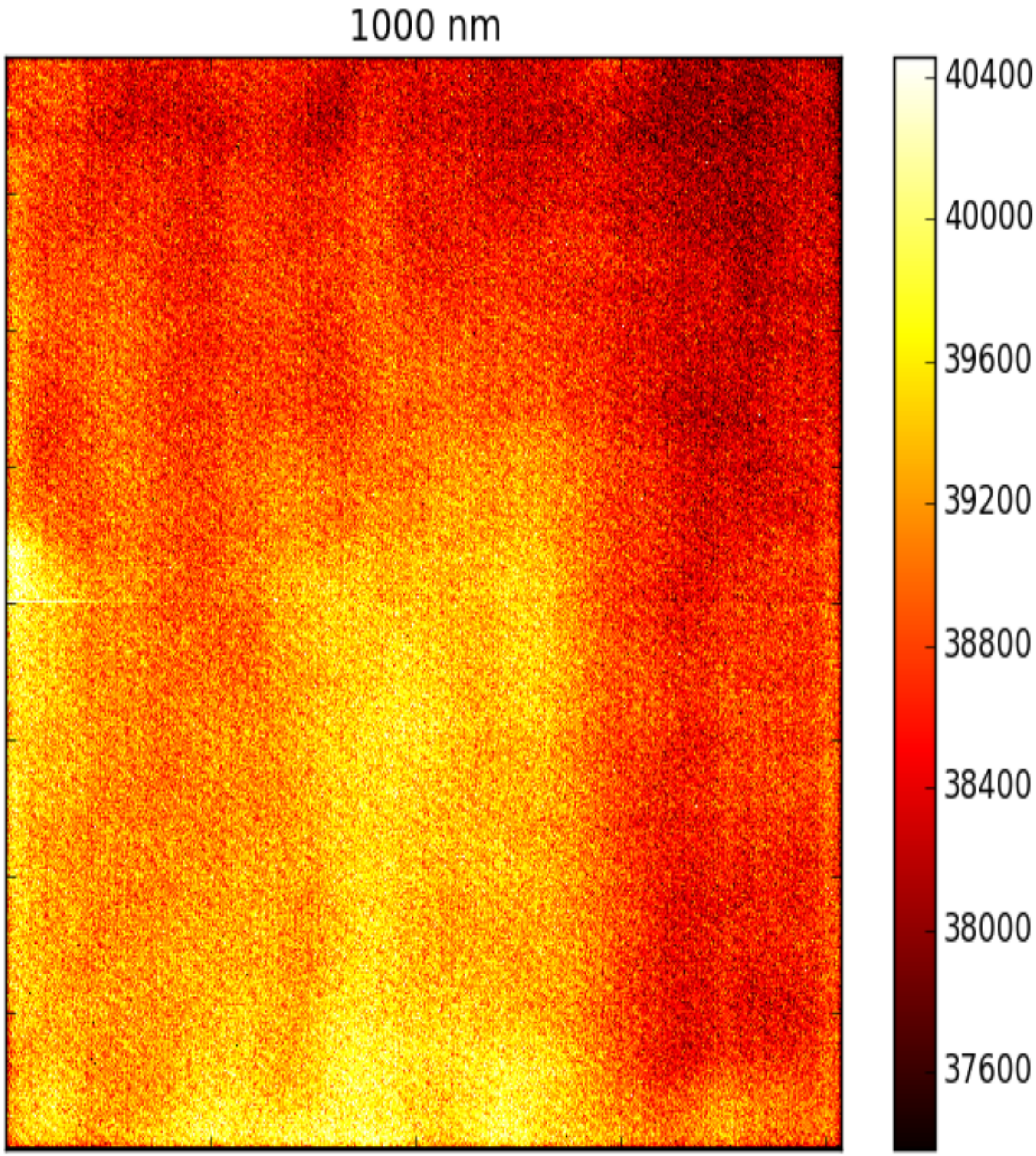
CCD – ITL-098: 450nm Response

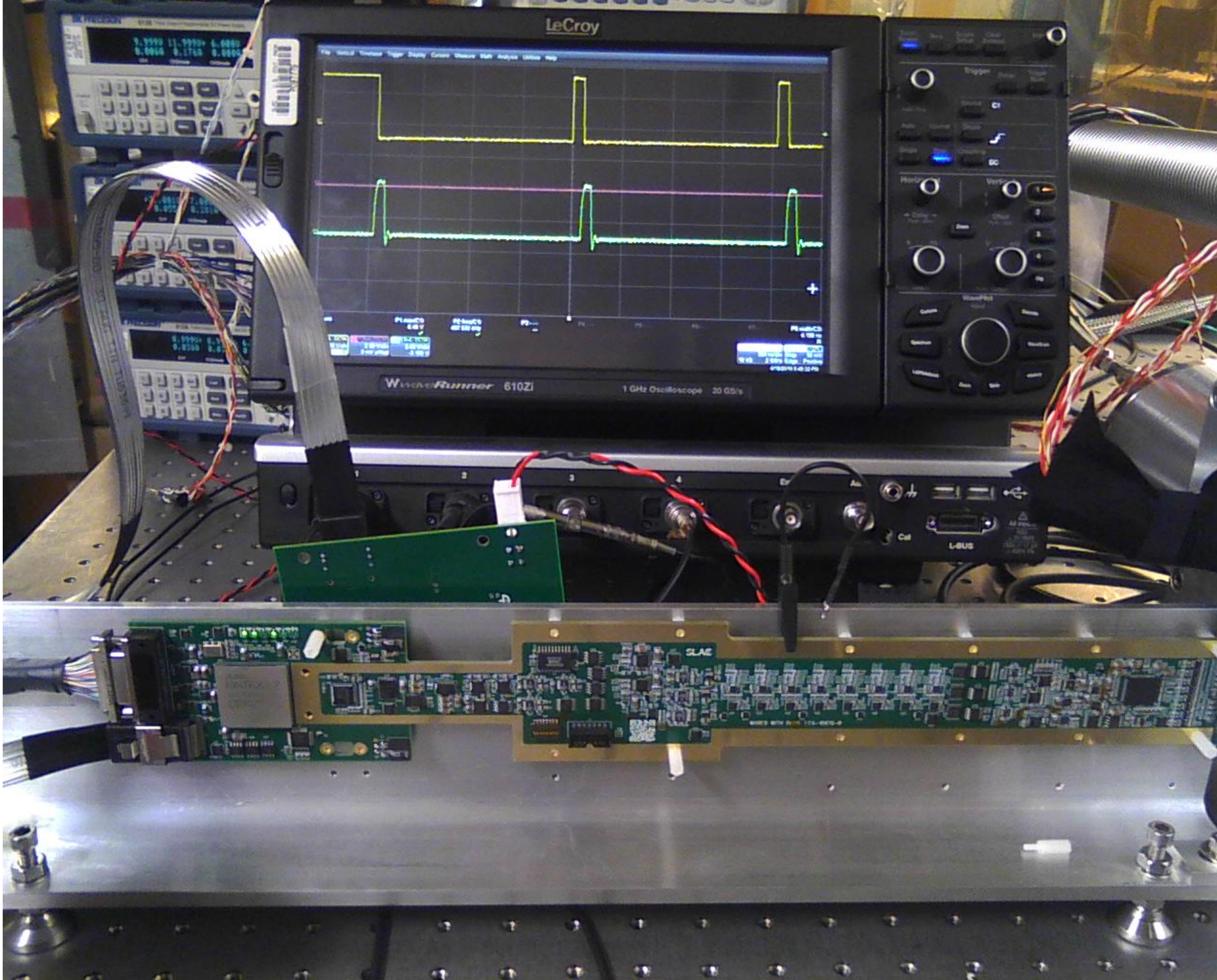


CCD – ITL-098: 870nm Response

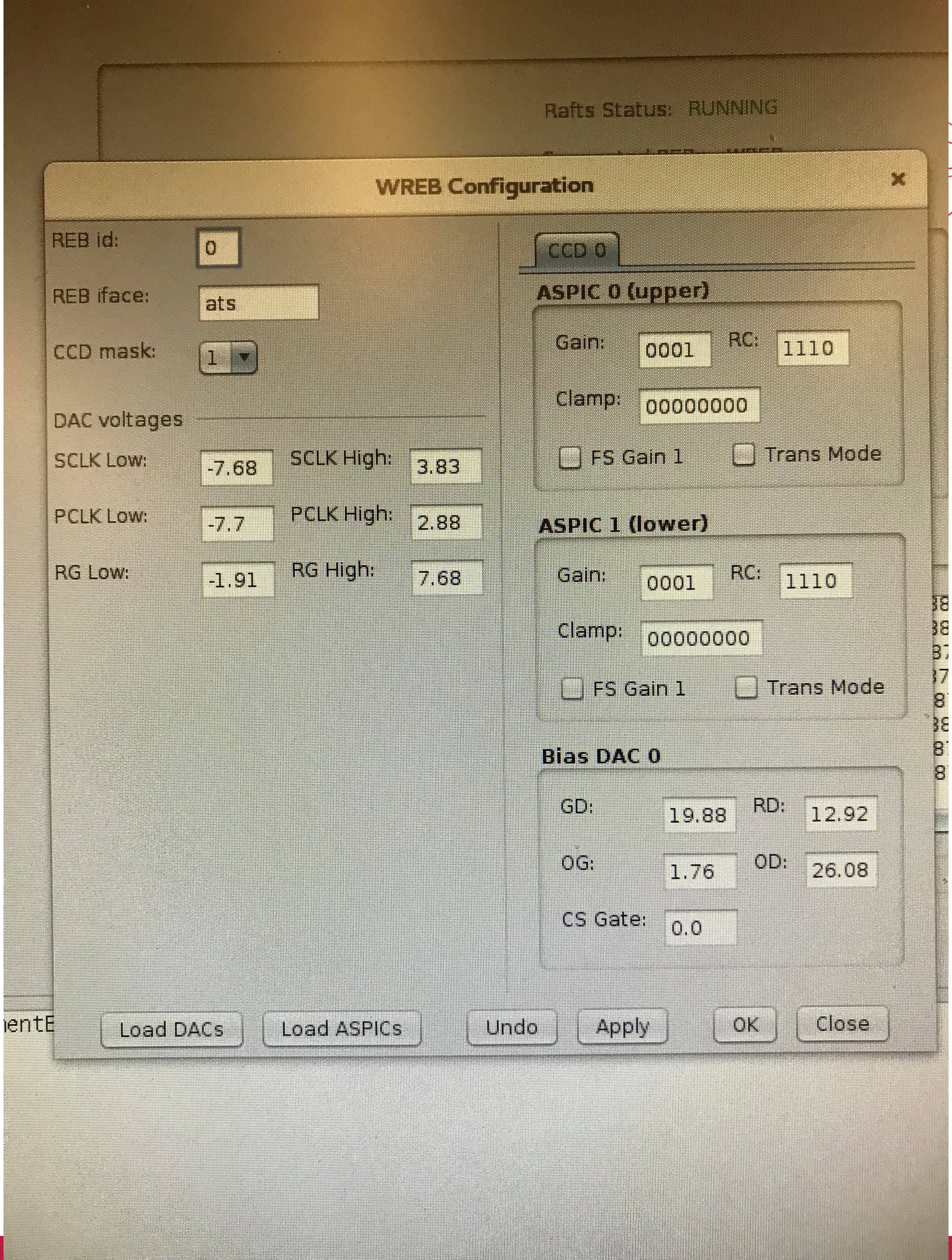


CCD– ITL-098: 1000nm Response



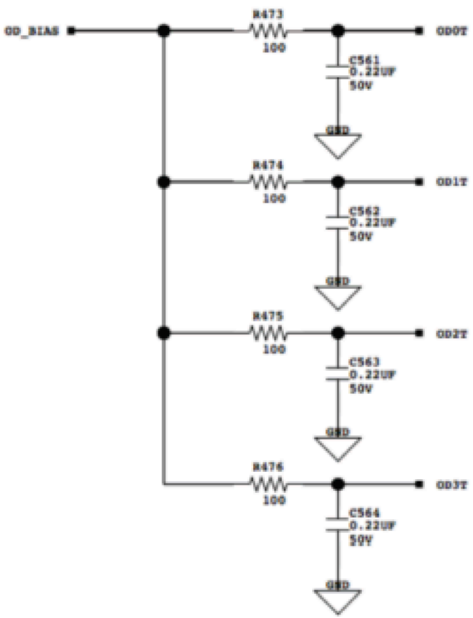

LeCroy
WaveRunner 610Zi
1 GHz Oscilloscope 20 GS/s
L-BUS
Cal
SLAC

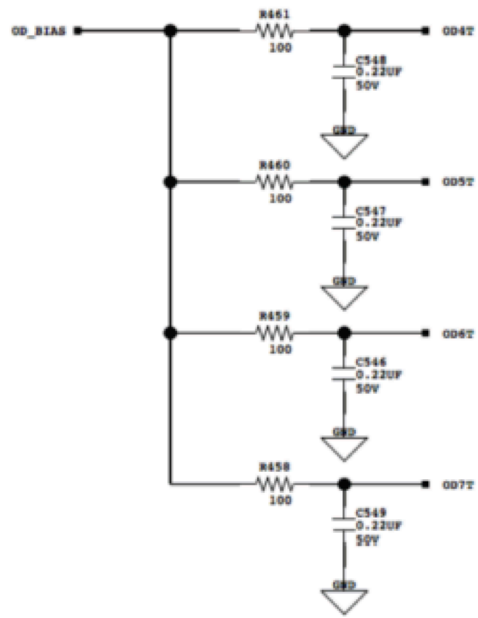
REB Voltages

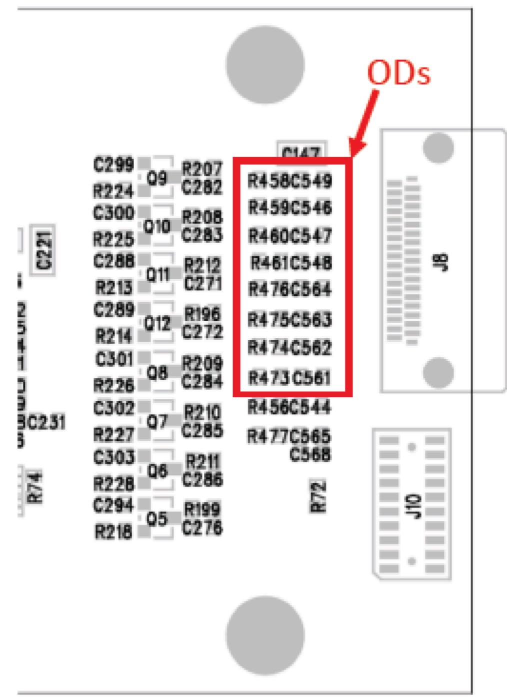


LSST DESC Dark Energy Science Collaboration

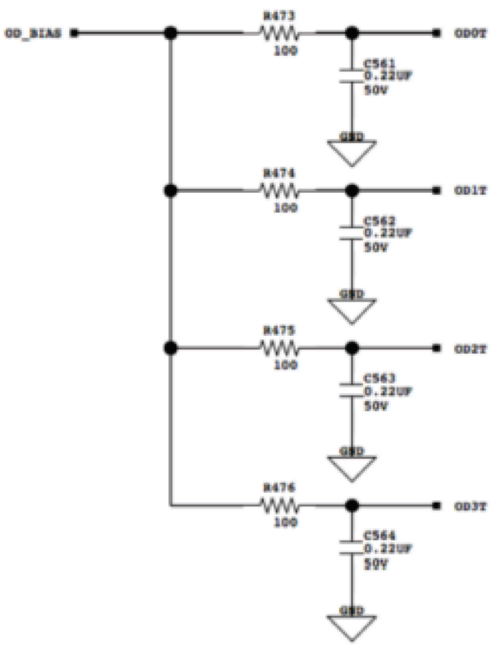
WREB Voltages

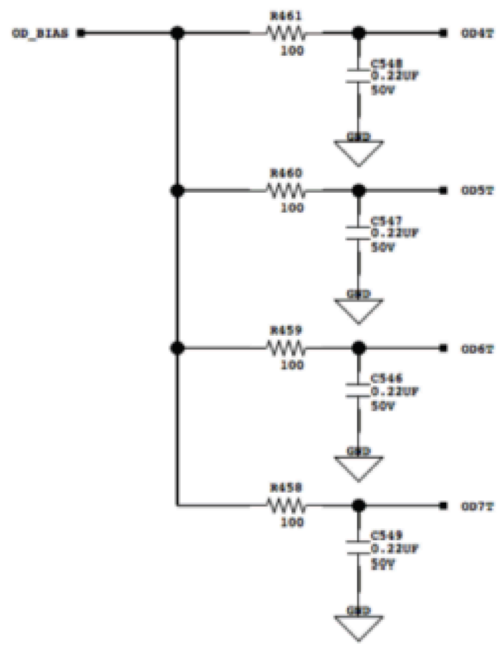


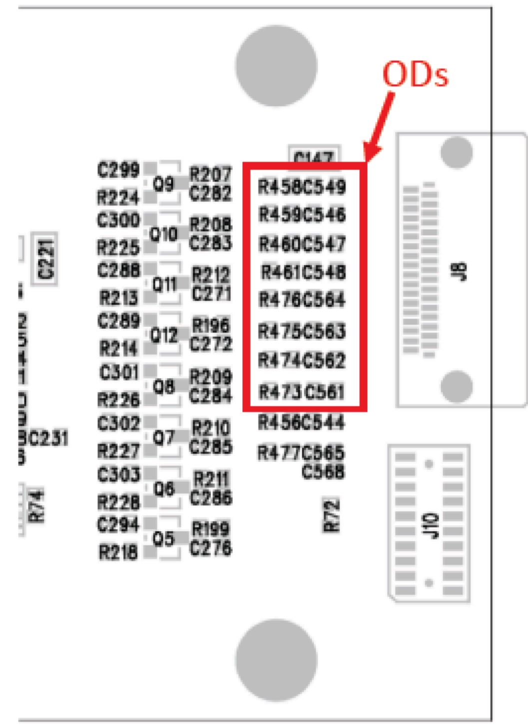




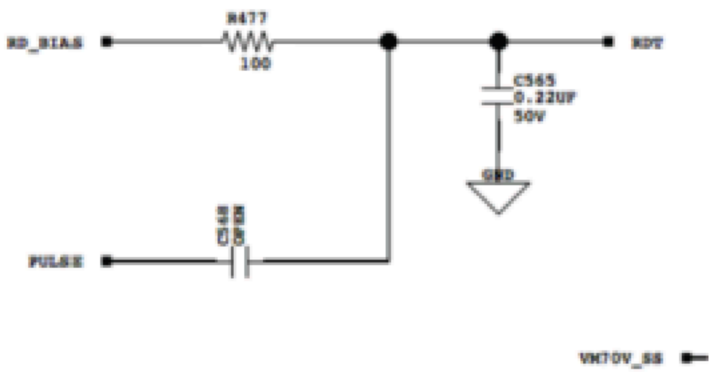
WREB Voltages (2)

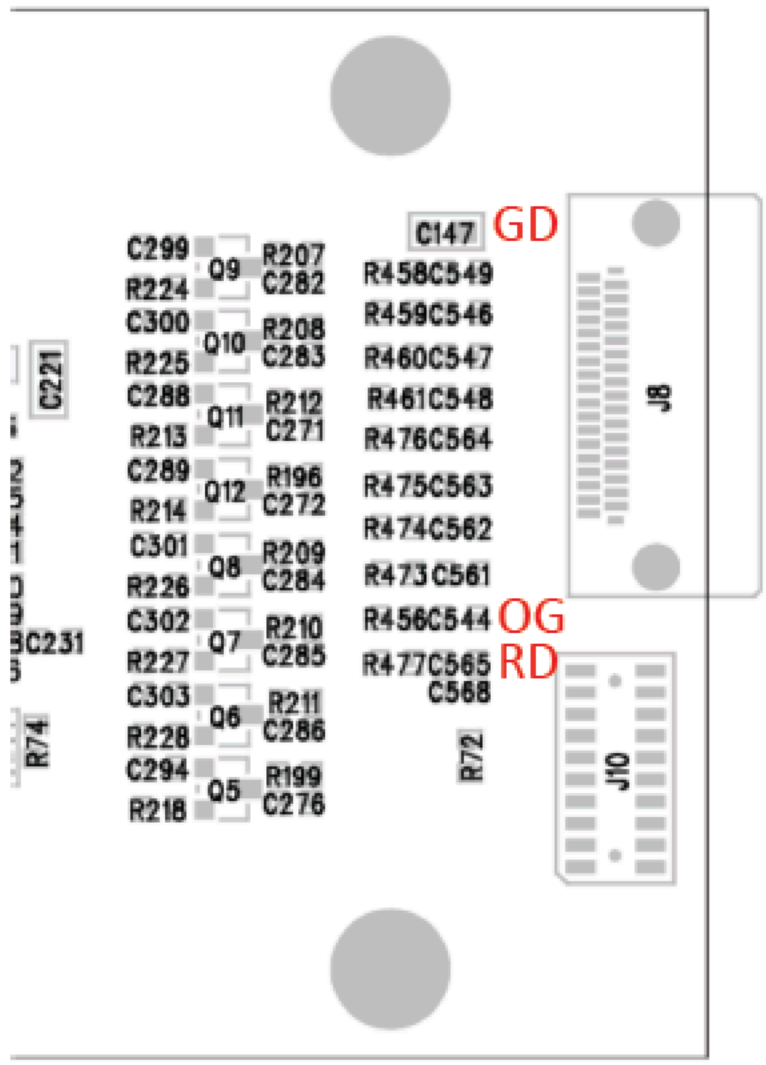






WREB Voltages (3)





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Setting  w  OG:  1.75
Loading DACs on w
Acquire Exposure:  Time =  17.667844523    Filebase =  scte_-9.00_04.00_01.75_000
Saved FITS image to /data/ats/2018-09-21/scte_-9.00_04.00_01.75_000_exp_17.6678_20180922032404.fits
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Loading DACs on w
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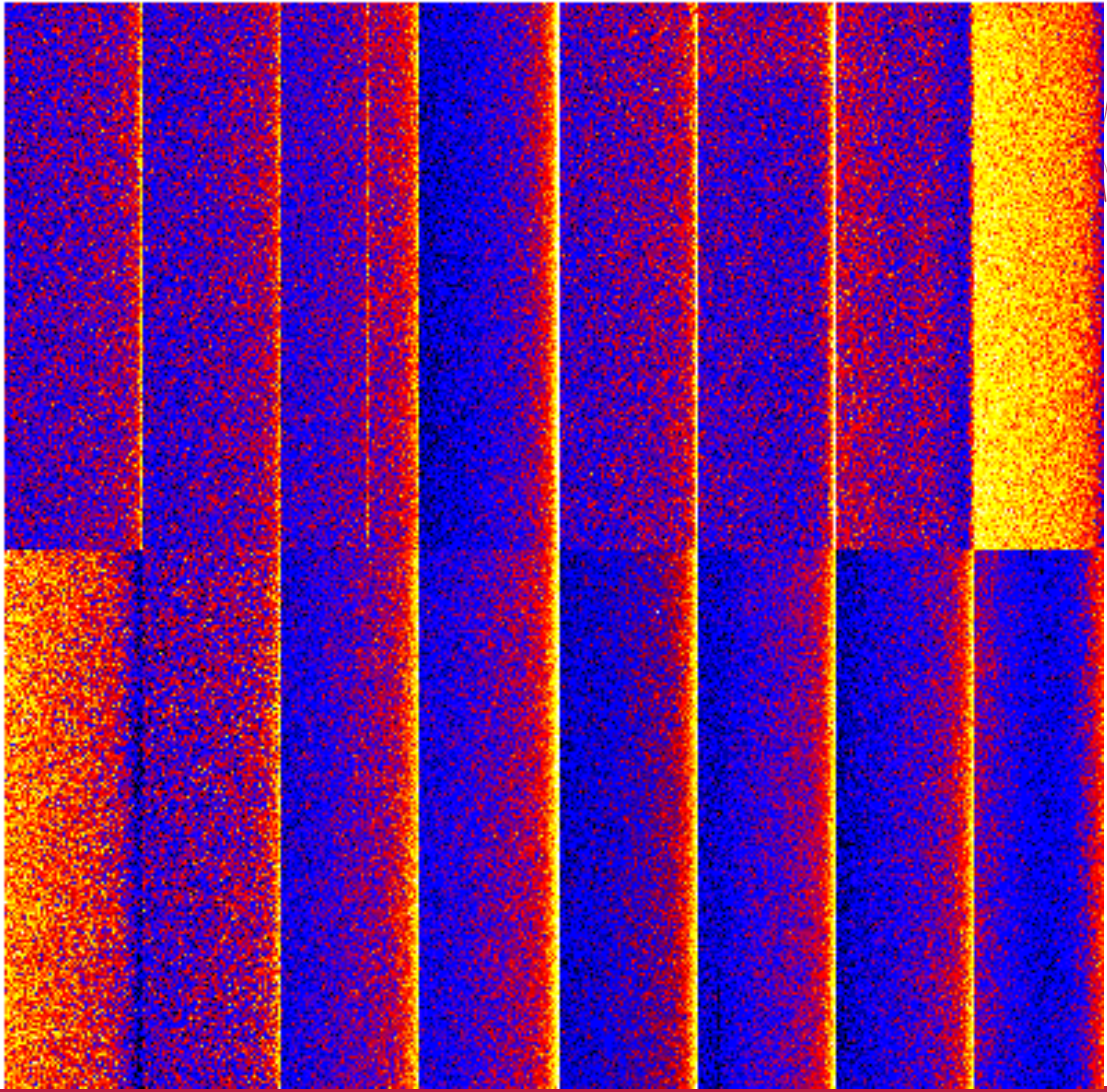
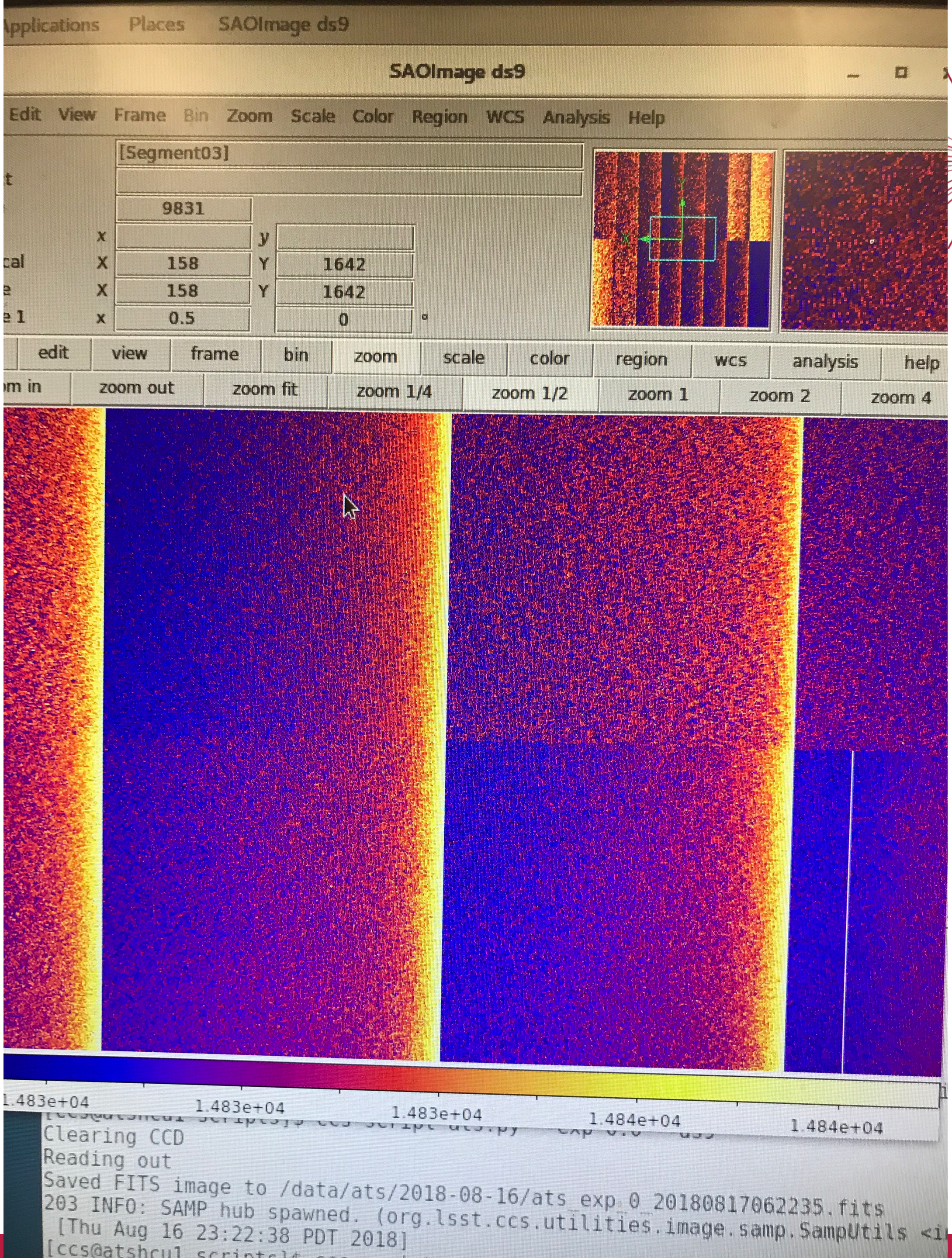
*** Failed to invoke main method in class org.lsst.ccs.subsystems.console.jython.JythonScriptExecutor
*** Reason:  null
Traceback (most recent call last):
  File "scte.py", line 34, in <module>
    acquireExposure(exptime, fbase)
  File "/lsst/ccs/20180913/etc/REBlib.py", line 350, in acquireExposure
    return readoutImage(fname)
  File "/lsst/ccs/20180913/etc/REBlib.py", line 316, in readoutImage
    result = raftsub.sendSynchCommand("waitForImage", 30000)
        at org.lsst.ccs.scripting.ScriptingSubsystemWrapper.internalSynchCommand(ScriptingSubsystemWrapper.java:75)
        at org.lsst.ccs.scripting.ScriptingSubsystemWrapper.sendSynchCommand(ScriptingSubsystemWrapper.java:59)
        at sun.reflect.GeneratedMethodAccessor29.invoke(Unknown Source)
        at sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)
        at java.lang.reflect.Method.invoke(Method.java:498)
org.lsst.ccs.scripting.ScriptingTimeoutException: org.lsst.ccs.scripting.ScriptingTimeoutException: timeout
FAILED TO EXECUTE:
exec java -Djava.net.preferIPv6Addresses=false -Djava.net.preferIPv4Stack=true -Djava.util.logging.manager=org.lsst.c
.logging.CCSLogManager -cp /lsst/ccs/20180913/org-lsst-ccs-ats-software-main-1.0.0-SNAPSHOT/share/java/org-lsst-ccs-a
main-1.0.0-SNAPSHOT.jar org.lsst.ccs.bootstrap.Bootstrap scte.py --ds9 --app ccs-script
[ccs@atshcu1 scripts]$
```



Bias Frame



Applications Places SAOImage ds9
SAOImage ds9
Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help
[Segment03]
9831
158 1642
158 1642
0.5 0
edit view frame bin zoom scale color region wcs analysis help
zoom out zoom fit zoom 1/4 zoom 1/2 zoom 1 zoom 2 zoom 4
1.483e+04 1.483e+04 1.483e+04 1.484e+04 1.484e+04
Clearing CCD
Reading out
Saved FITS image to /data/ats/2018-08-16/ats_exp_0_20180817062235.fits
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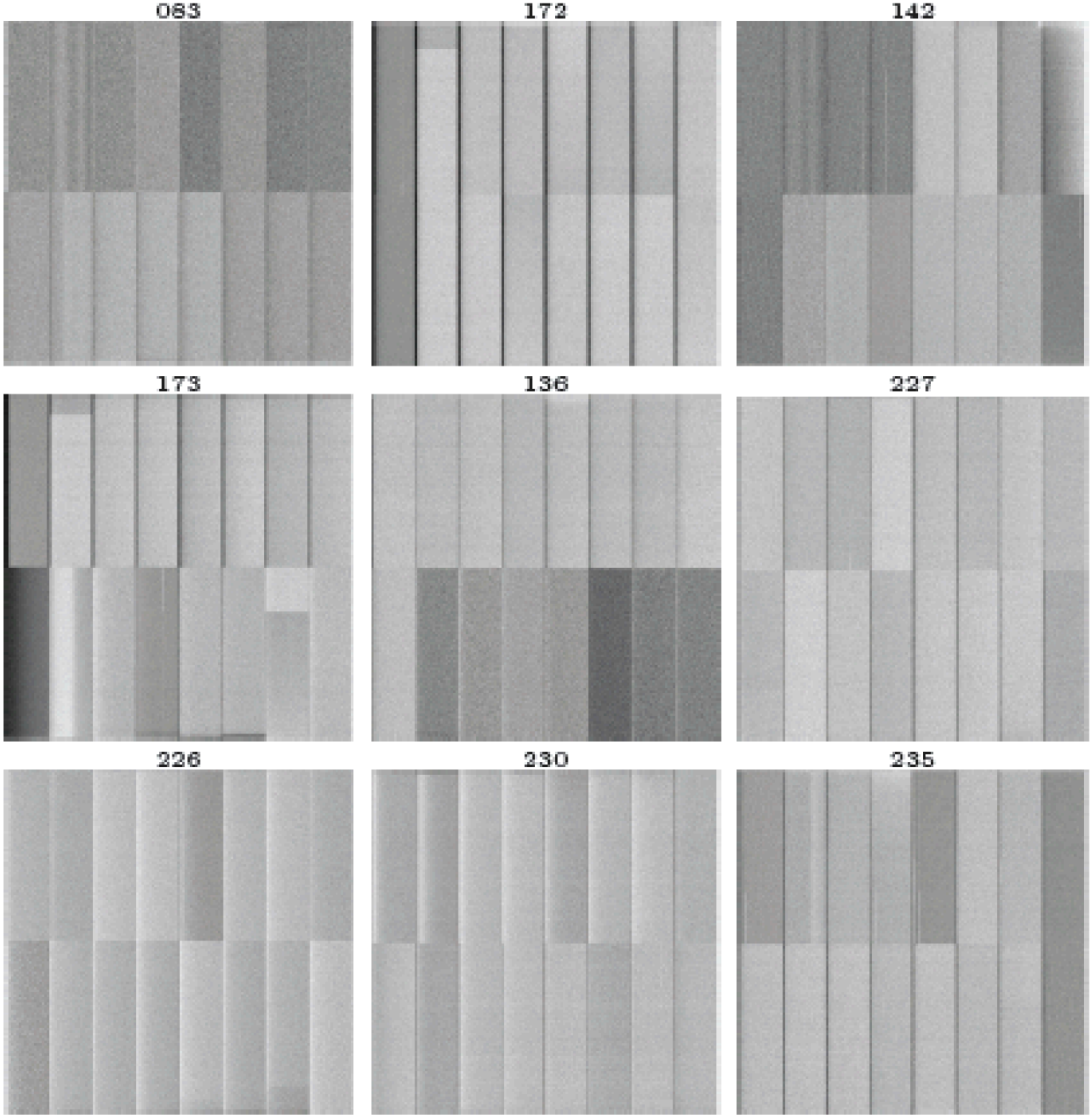
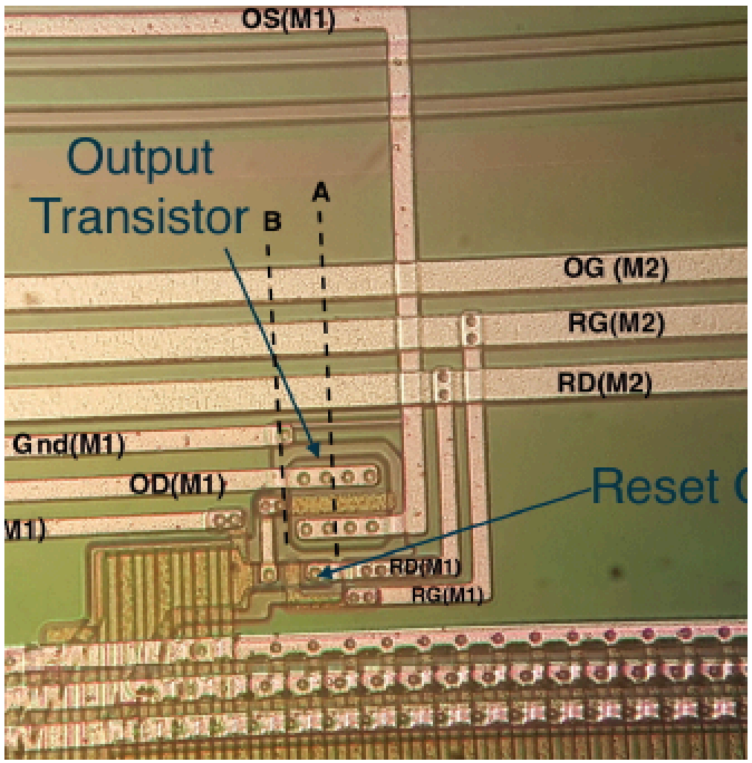
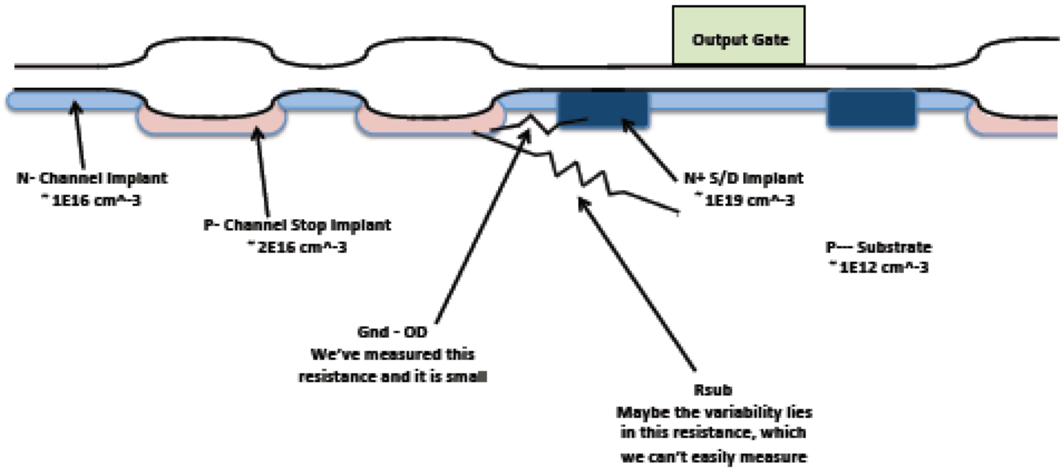
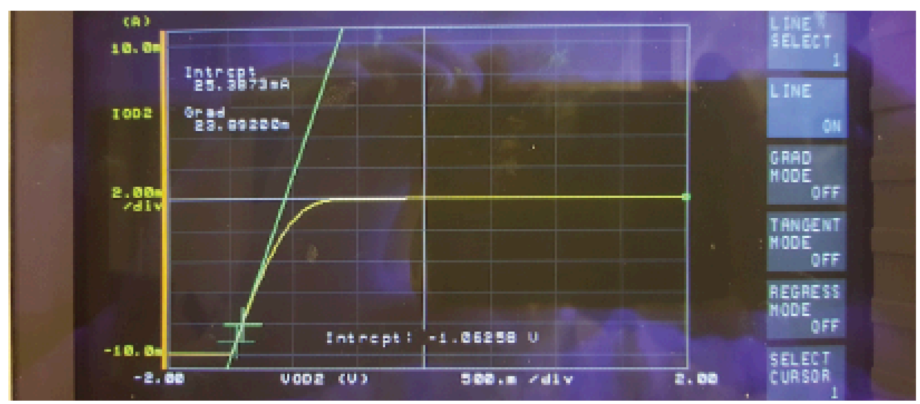
[Thu Aug 16 23:22:38 PDT 2018]

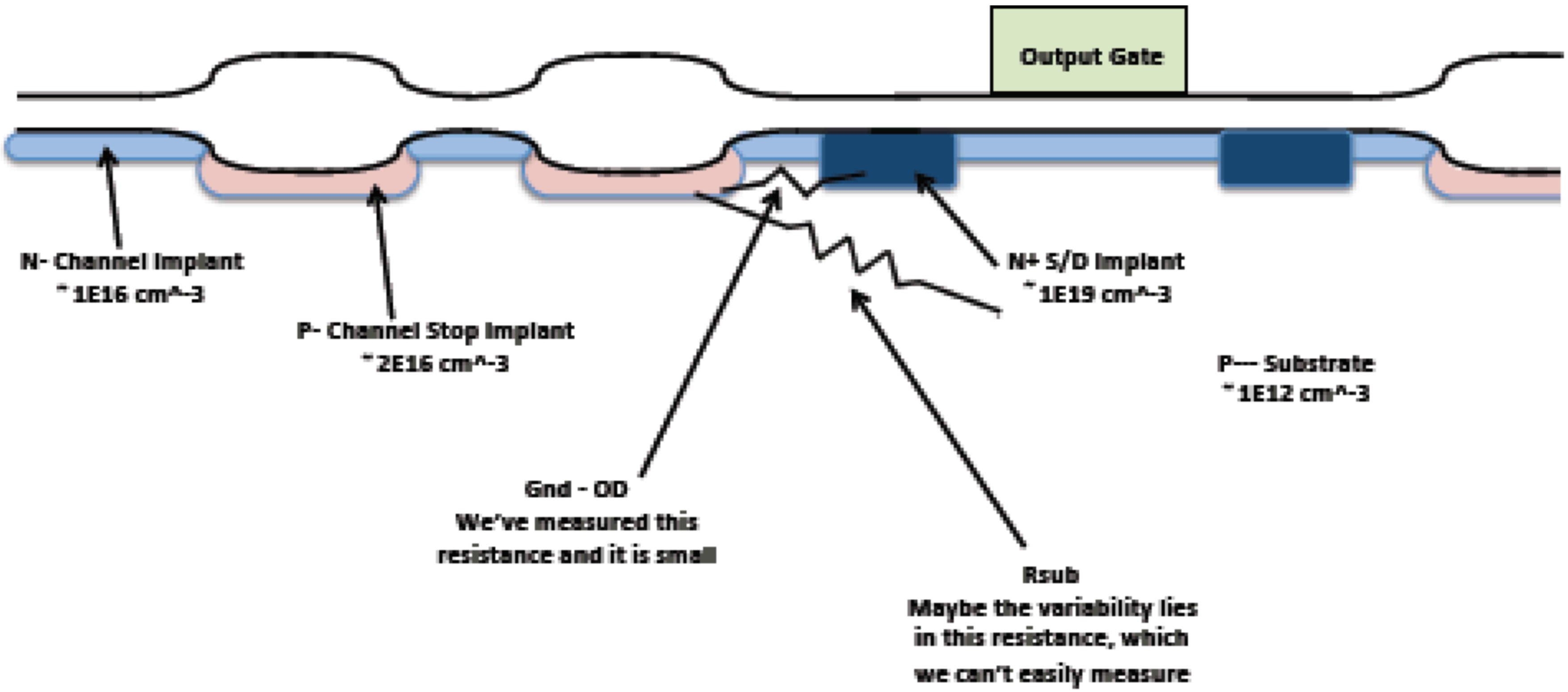

083
172
142
173
136
227
226
230
235

LSST CCD Output Geometry

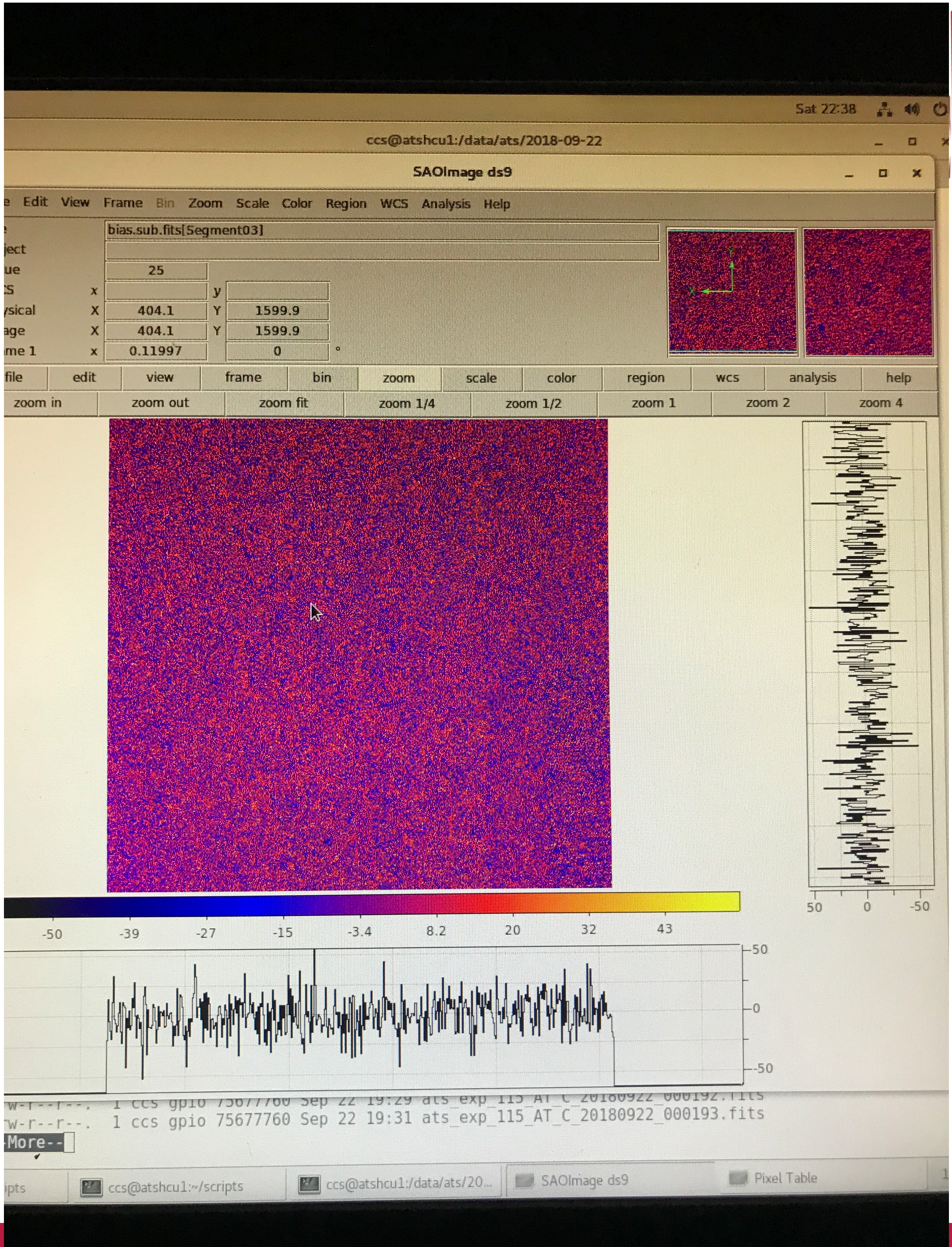







Output Gate
N- Channel Implant
~1E16 cm^-3
P- Channel Stop Implant
~2E16 cm^-3
N+ S/D Implant
~1E19 cm^-3
P--- Substrate
~1E12 cm^-3
Gnd - OD
We've measured this
resistance and it is small
Rsub
Maybe the variability lies
in this resistance, which
we can't easily measure

Bias Subtraction over three days



WREB Temperature regulation

Temperature Regulation

From the SoW (LTS-520 v1.0):

2.1.3 Raft Electronics Board Temperature Control

The Contractor shall provide all equipment and control software necessary to control the temperature of the Raft electronics board.

Discussion:

This requires that the contractor provide a thermal control system for the electronics.

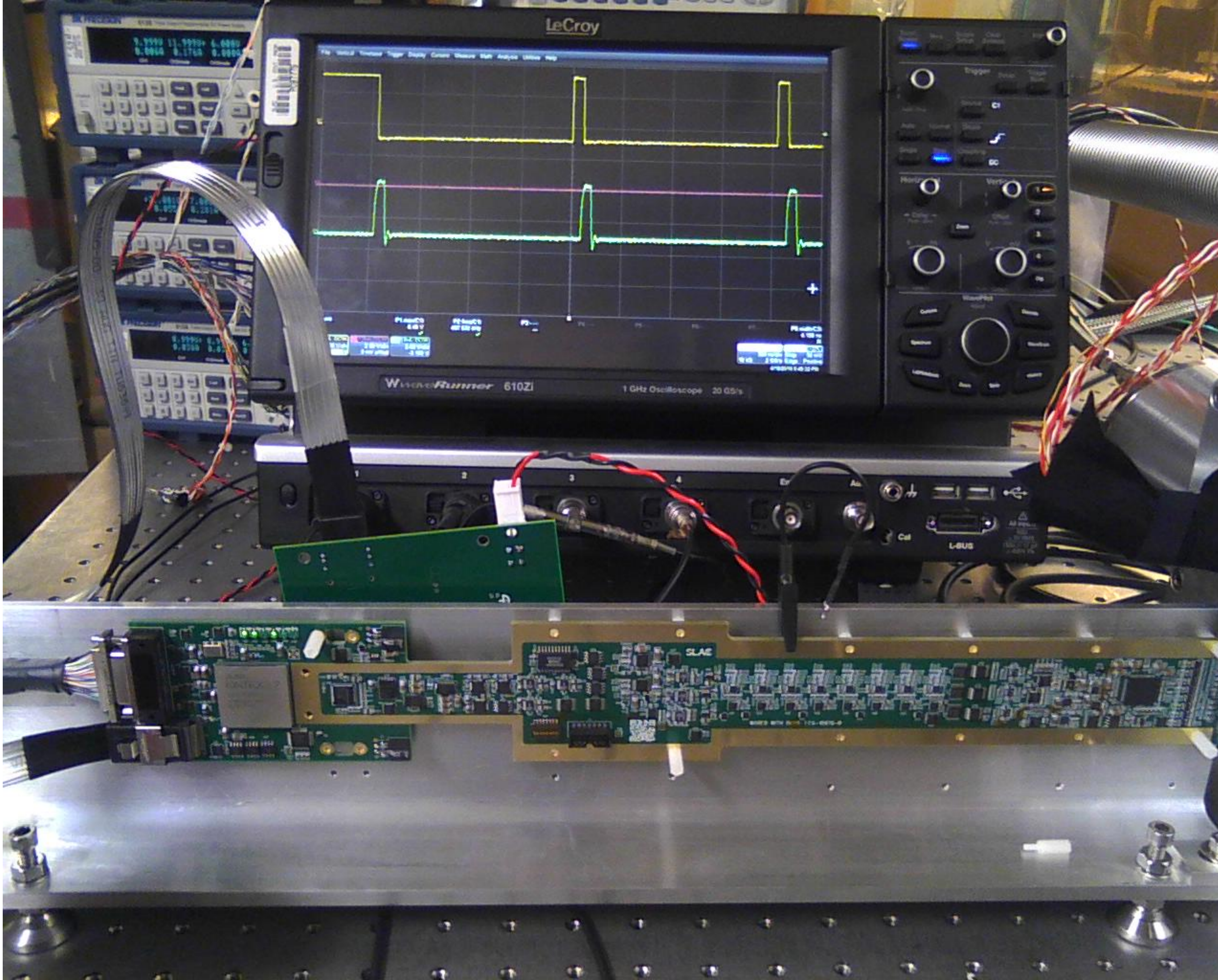
2.5 Readout Electronics Thermal Control and Monitoring

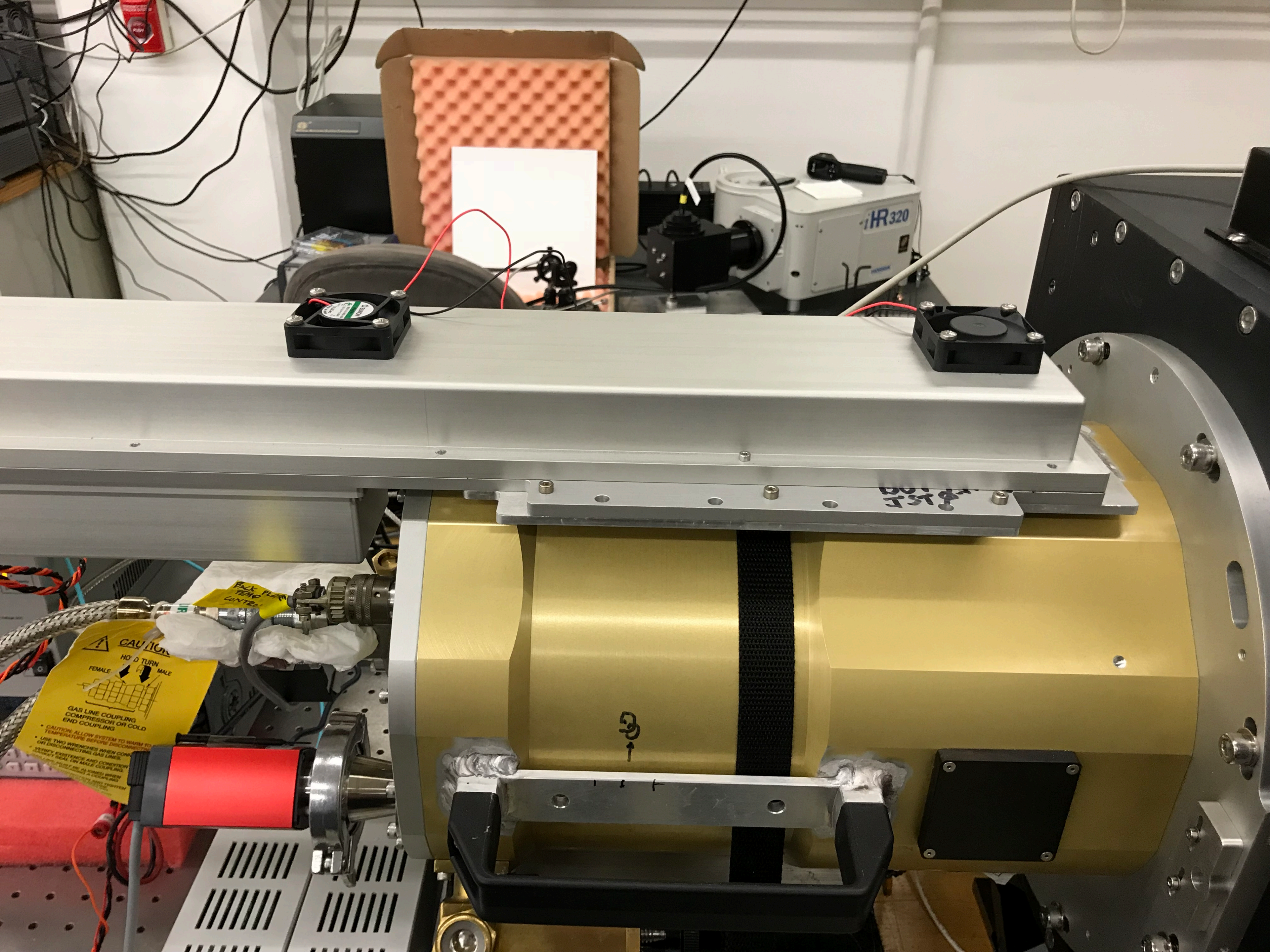
The electronics board temperatures will be monitored and controlled to a user-defined setpoint using sensors that have an accuracy of no worse than

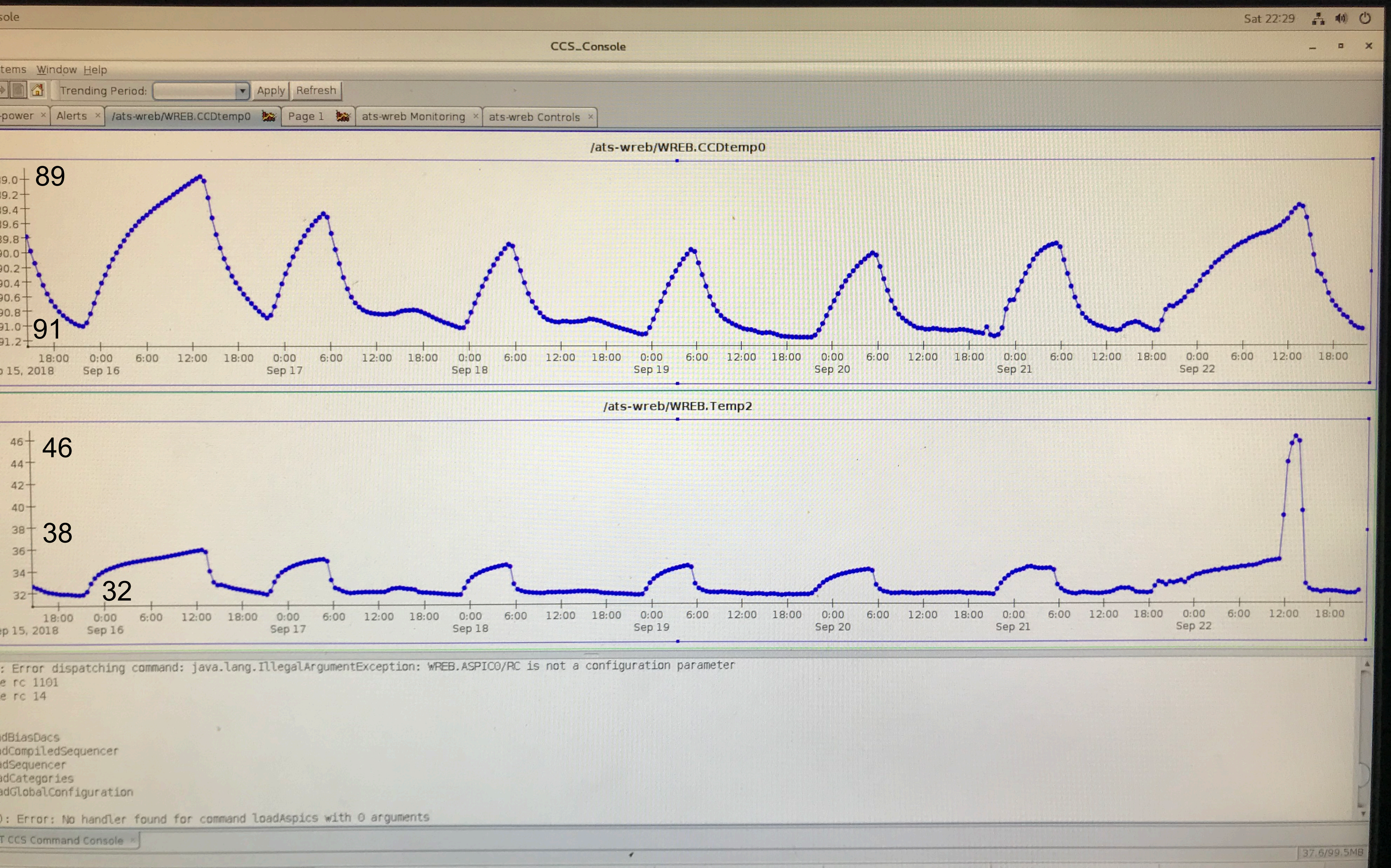
+/- 1degree C. Requirements on this system are defined in LTS-521.

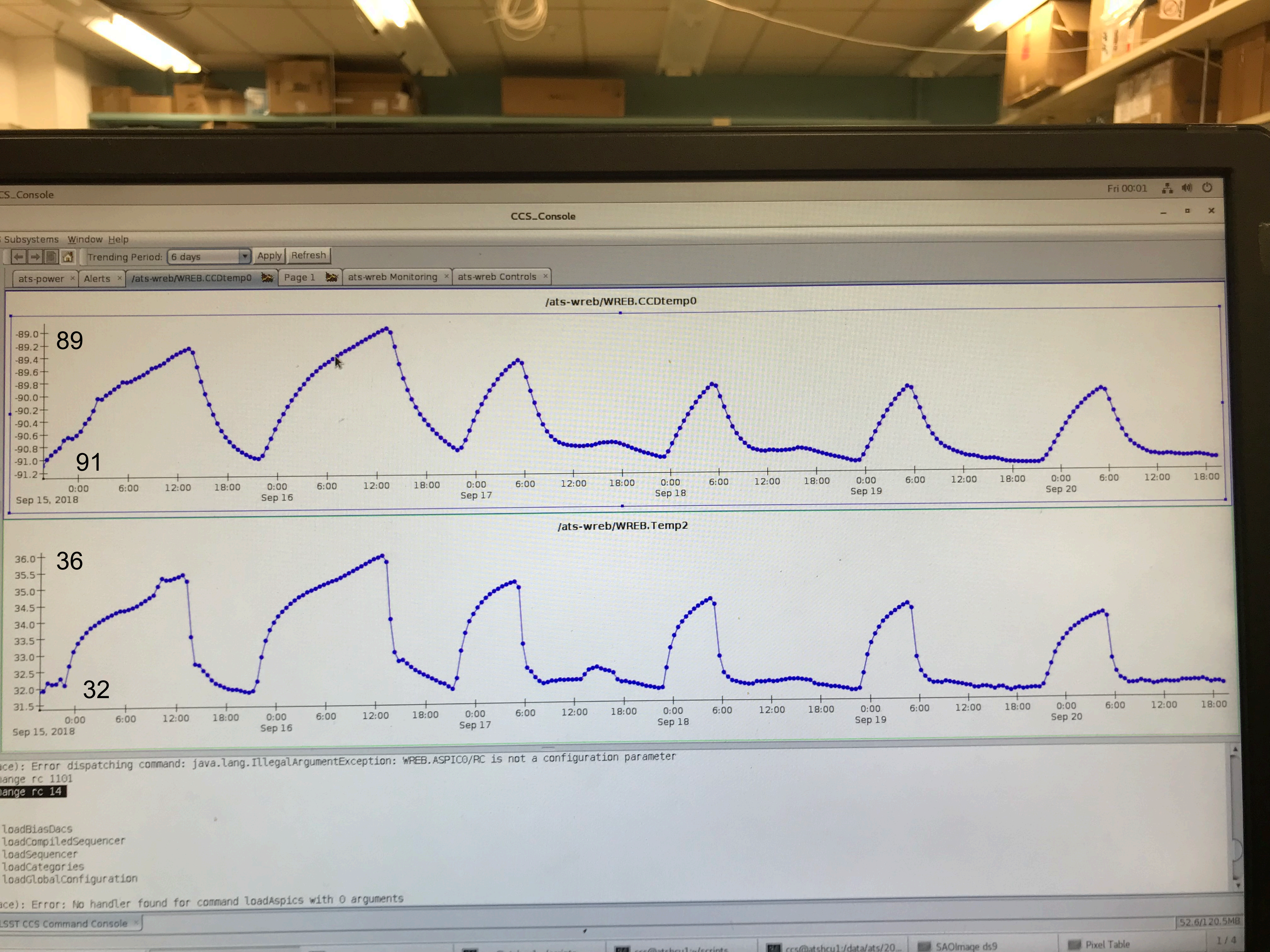
This system will consist of a fan for removing air, an electrical heating element and the associated electronics and controls.

Proposal: The REB will be housed between a pair of copper plates identical in design to those used in the LSSTcam Corner Raft Tower Module. An RTD temperature sensor (Lakeshore Model PT-103-AM) and heating element (Lakeshore Model HTR-50) will be added to those copper plates. A programmable temperature controller (Lakeshore Model 336) will be used to regulate the temperature of those copper plates and therefore the REB. Additionally, the REB includes temperature sensors which may be read through the CCS system to measure temperature of the PCB itself. A small mechanical fan will be used to circulate air through the REB housing

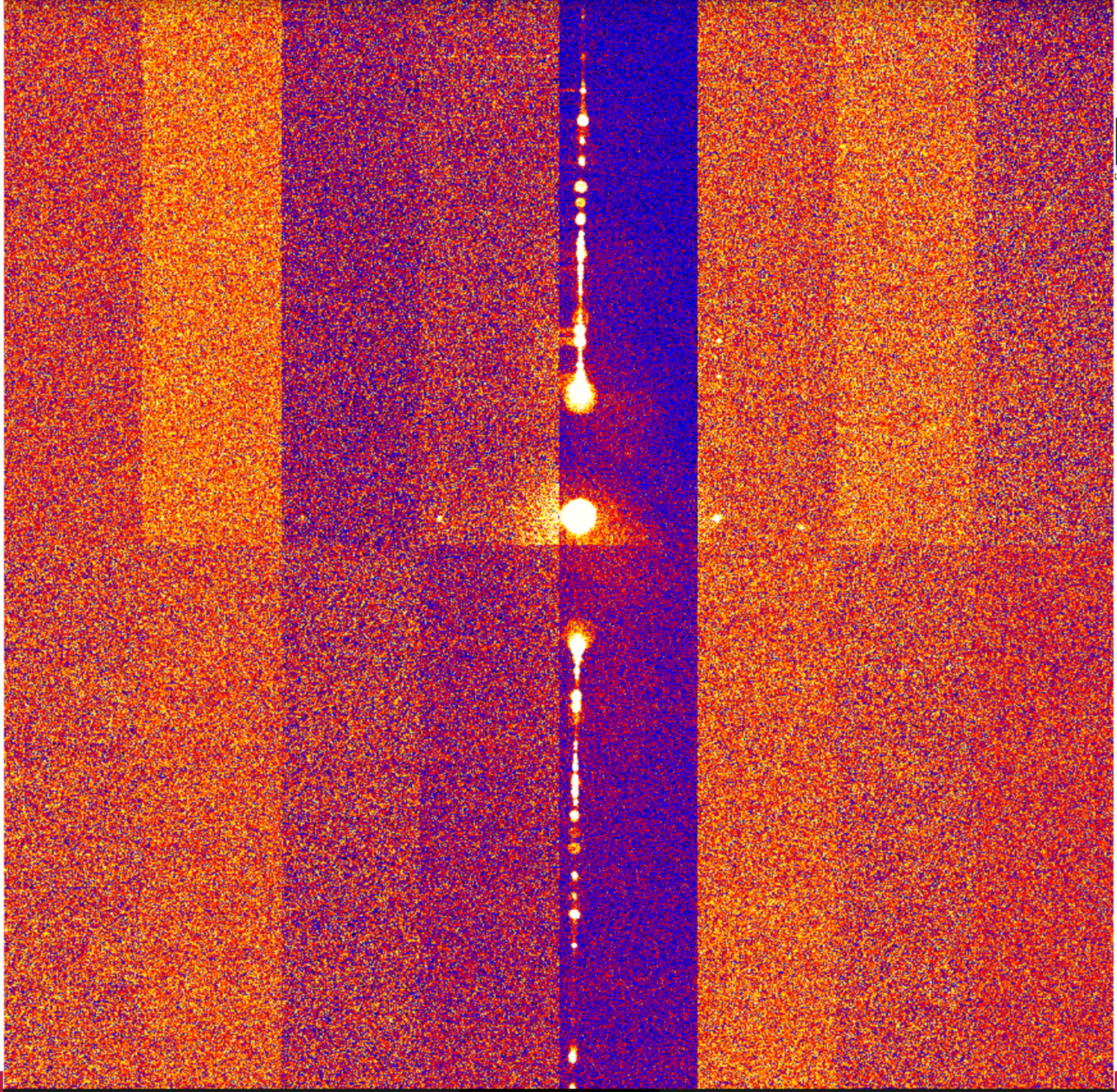

LeCroy
WaveRunner 610Zi
1 GHz Oscilloscope 20 GS/s
L-BUS
Cal
SLAC


iHR320
FEMALE
MALE
GAS LINE COUPLING
COMPRESSOR OR COLD
END COUPLING

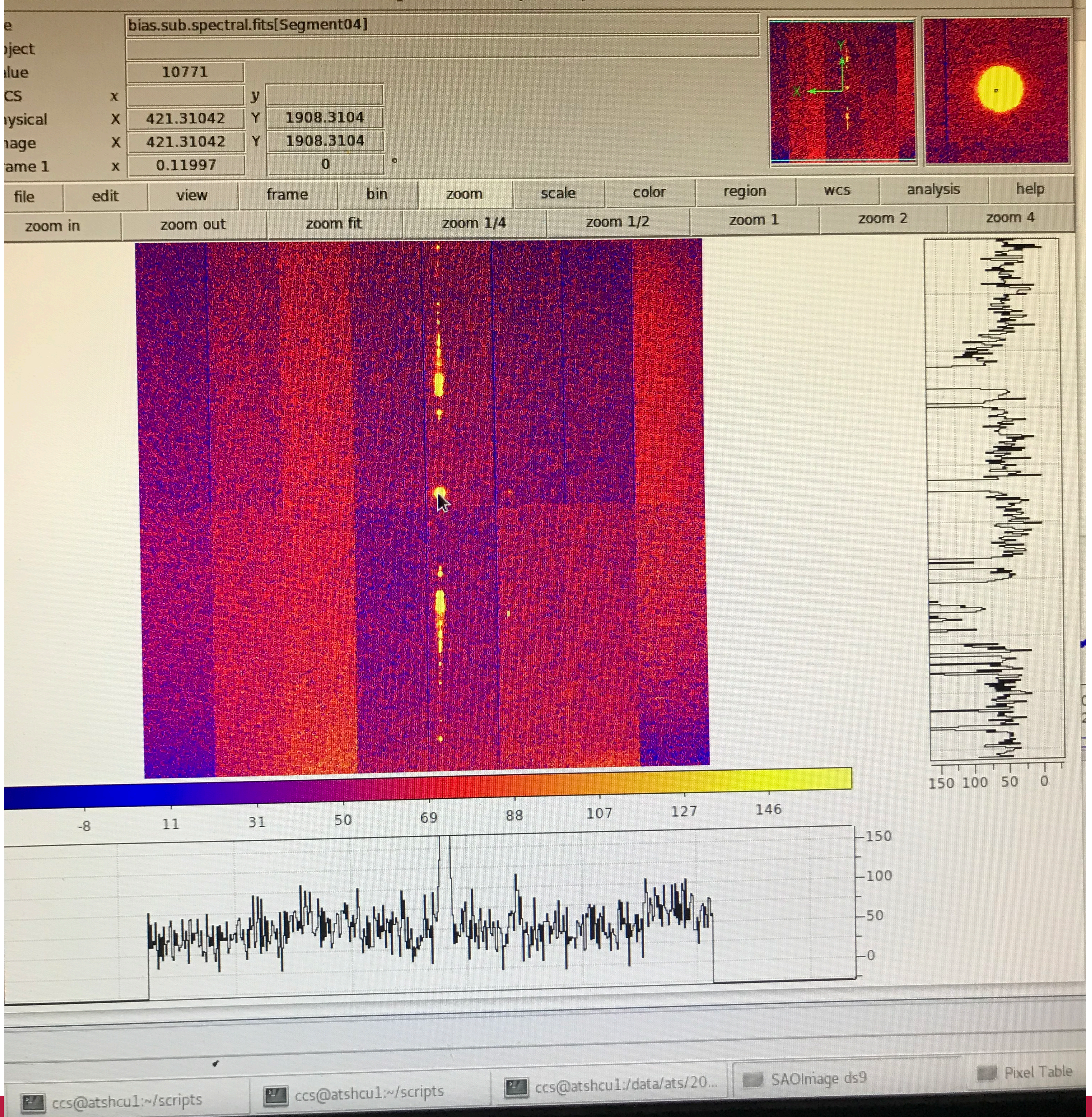

sole
Sat 22:29
CCS_Console
tems Window Help
Trending Period: Apply Refresh
-power Alerts /ats-wreb/WREB.CCDtemp0 Page 1 ats-wreb Monitoring ats-wreb Controls
/ats-wreb/WREB.CCDtemp0
89
91
18:00 0:00 6:00 12:00 18:00 0:00 6:00 12:00 18:00 0:00 6:00 12:00 18:00 0:00 6:00 12:00 18:00 0:00 6:00 12:00 18:00 0:00 6:00 12:00 18:00 0:00 6:00 12:00 18:00
p 15, 2018 Sep 16 Sep 17 Sep 18 Sep 19 Sep 20 Sep 21 Sep 22
/ats-wreb/WREB.Temp2
46
38
32
46 44 42 40 38 36 34 32
: Error dispatching command: java.lang.IllegalArgumentException: WREB.ASPIC0/RC is not a configuration parameter
e rc 1101
e rc 14
dBiasDacs
dCompiledSequencer
dSequencer
dCategories
adGlobalConfiguration
): Error: No handler found for command loadAspics with 0 arguments
CCS Command Console
37.6/99.5MB

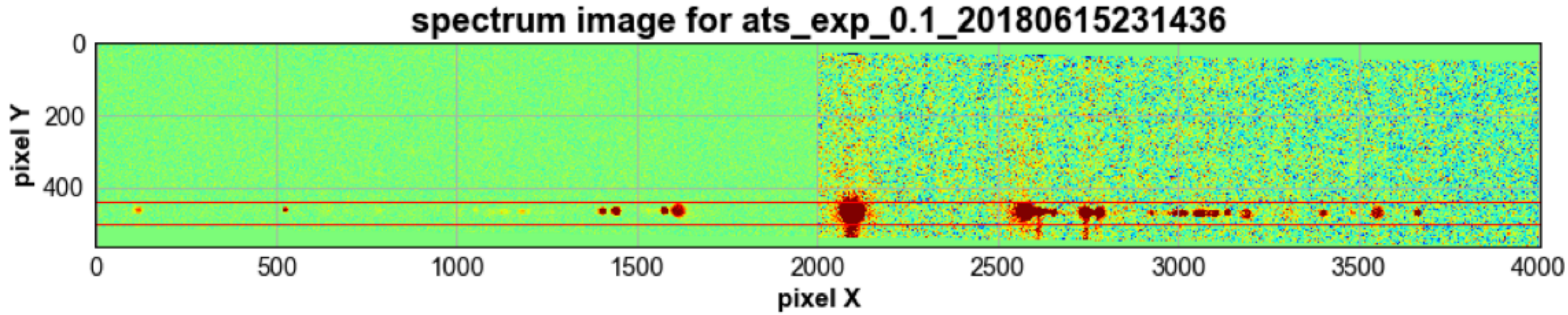

CS_Console
Fri 00:01
CCS_Console
Subsystems Window Help
Trending Period: 6 days
Apply
Refresh
ats-power
Alerts
/ats-wreb/WREB.CCDtemp0
Page 1
ats-wreb Monitoring
ats-wreb Controls
/ats-wreb/WREB.CCDtemp0
-89.0
-89.2
-89.4
-89.6
-89.8
-90.0
-90.2
-90.4
-90.6
-90.8
-91.0
-91.2
89
91
0:00
6:00
12:00
18:00
Sep 15, 2018
Sep 16
Sep 17
Sep 18
Sep 19
Sep 20
/ats-wreb/WREB.Temp2
36.0
35.5
35.0
34.5
34.0
33.5
33.0
32.5
32.0
31.5
36
32
ce): Error dispatching command: java.lang.IllegalArgumentException: WREB.ASPIC0/RC is not a configuration parameter
ange rc 1101
ange rc 14
loadBiasDacs
loadCompiledSequencer
loadSequencer
loadCategories
loadGlobalConfiguration
ce): Error: No handler found for command loadAspics with 0 arguments
LSST CCS Command Console
52.6/120.5MB
SAOImage ds9
Pixel Table
1 / 4

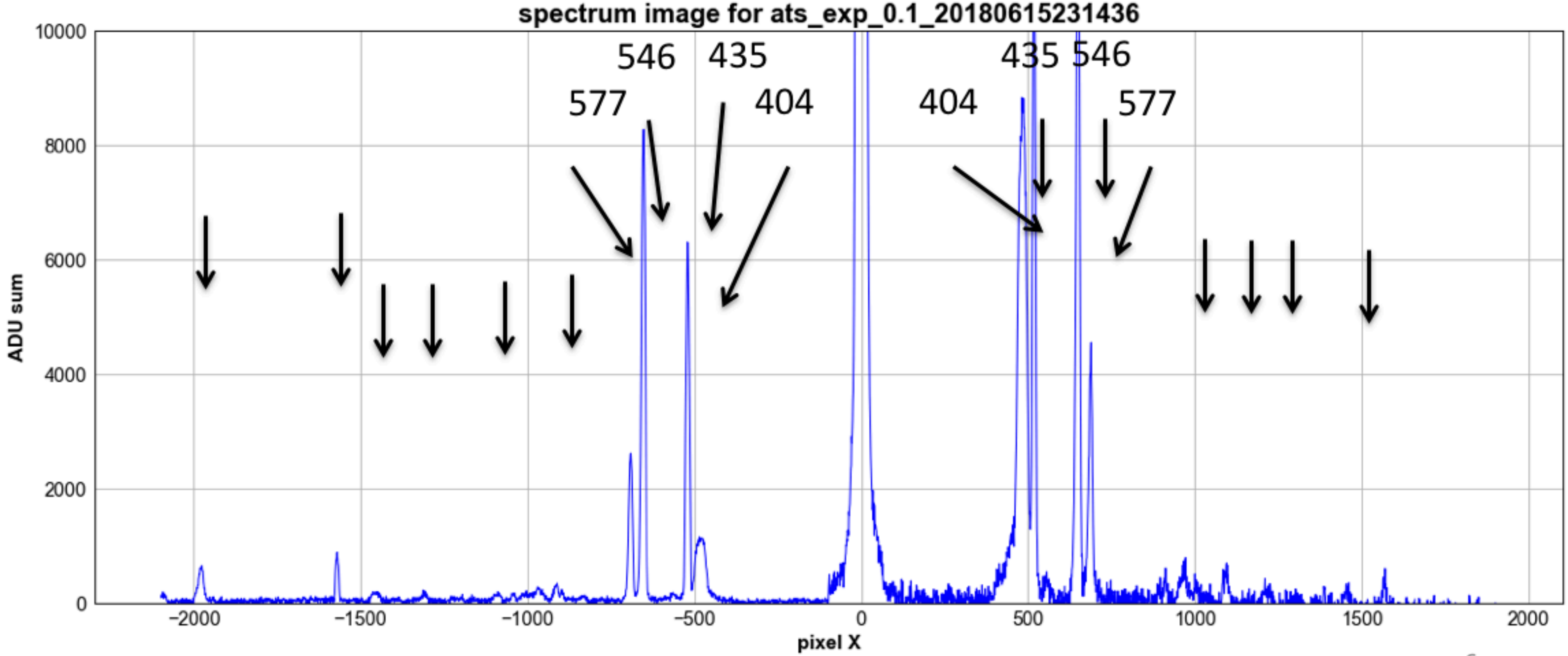

REMOTE
SENSE
max. 150 Vpk
CRYO·CON 24C Temperature Controller
1A:Channel A
180.967K
250.000K
2B:Channel B
128.898K
150.000K
3C:Channel C
160.499K
200.000K
4D:Channel D
100.000
Control
Alarm
Remote
Power
Stop
Control
Home
Enter
ChA
ChB
Esc
Options
Sensors
Config
System
Display
OUTPUT
MENU
REMOTE
SENSE
max. 150 Vpk
HARVARD UNIVERSITY
E10205
KEITHLEY
A Tektronix Company
REM
OUTPUT

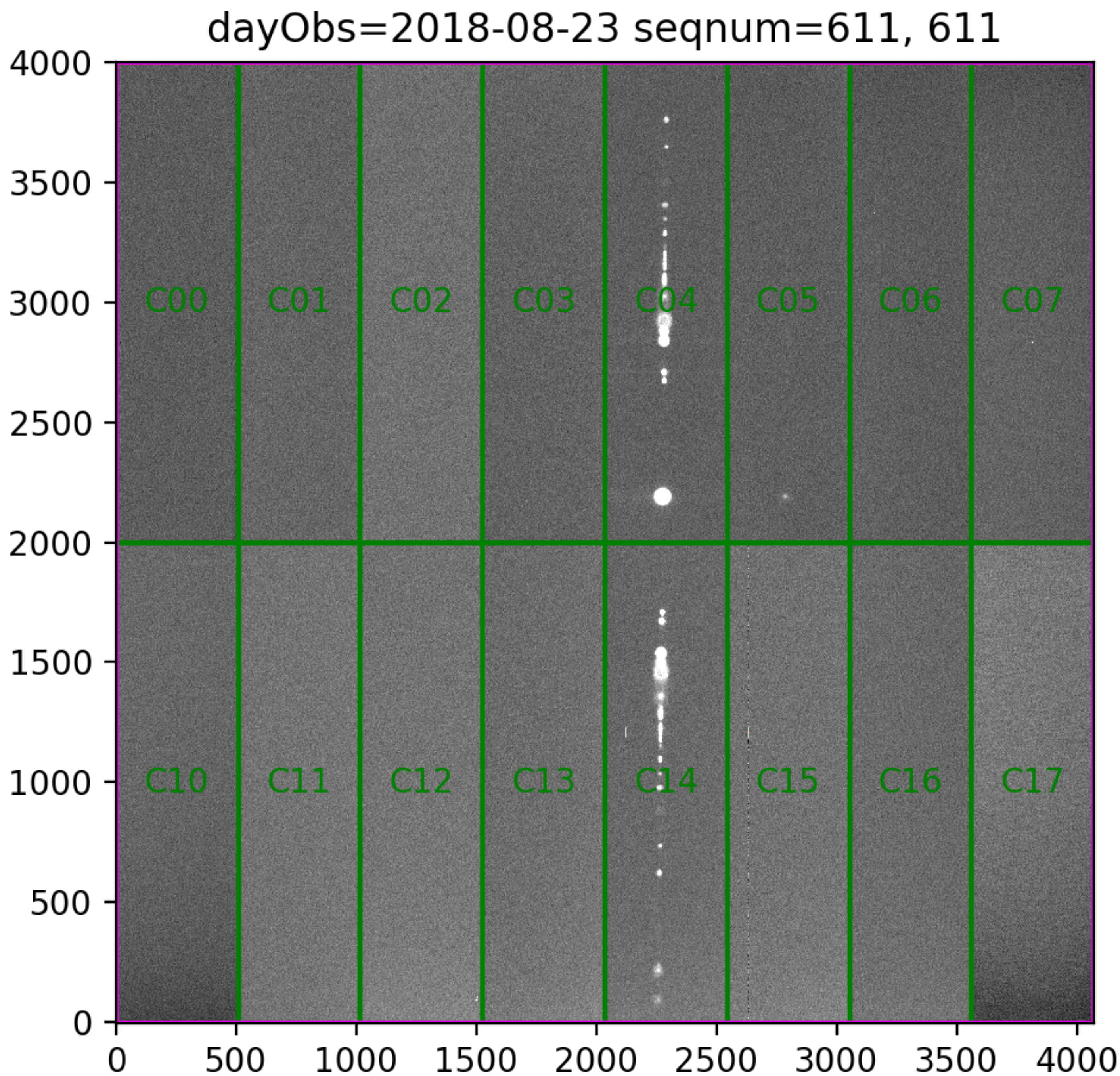


HgAr lamp


bias.sub.spectral.fits[Segment04]
10771
421.31042
1908.3104
421.31042
1908.3104
0.11997
0
file
edit
view
frame
bin
zoom
scale
color
region
wcs
analysis
help
zoom in
zoom out
zoom fit
zoom 1/4
zoom 1/2
zoom 1
zoom 2
zoom 4
-8 11 31 50 69 88 107 127 146
150 100 50 0
ccs@atshcu1:~/scripts
ccs@atshcu1:~/scripts
ccs@atshcu1:/data/ats/20...
SAOImage ds9
Pixel Table


spectrum image for ats_exp_0.1_20180615231436
pixel Y
pixel X


spectrum image for ats_exp_0.1_20180615231436
546
435
577
404
404
435
546
577
ADU sum
pixel X


dayObs=2018-08-23 seqnum=611, 611
C00
C01
C02
C03
C04
C05
C06
C07
C10
C11
C12
C13
C14
C15
C16
C17
0
500
1000
1500
2000
2500
3000
3500
4000

There were multiple data sets taken with the ATS camera last week. All data are resident in the CCS machine in Tucson in /data/ats. The directory listing is much easier to follow if you display in chronological order.

1. Spectra - Dir 2018-09-20

    Contains multiple bias frames before and after spectra frames.
    Bias frames at the beginning start/end with files #28/#37
    spectra files start with file #28
    Spectra starts w/1s exp and increments in 1s intervals to 31s.
    last spectra file isn't # 69 (31s)
    bias frames at the end start/end with files #70/#79

N.B. Data taken with an Edmund Ronchi grating. Science gratings not yet installed

2. Serial CTE scan - Dir 2018-09-21

    See attached scte.py for detail scan information.
    Image file names contain voltage scan parameters for that particular file.
    This script was executed to determine/confirm serial and output gate voltages that have been incorporated into the system to be very close to optimum during initial camera characterization/optimization.

Serial CTE as taken by the scte.py script and subsequent analysis may indicate that minor serial clocks and OG may improve performance.

3. Flat scans - Dir 2018-09-22

Flat Scan 1 bias frames at the beginning of the scan start/end with file 10/19.
Flat pair sequence starts at 1s
exp. time (~2500dn) and increments in 1s intervals up
to ~100s when the script then takes flat pairs in 5s intervals
up to 130s. A bias series
is then taken.

Flat scan 1 starts with the 2s sequencer(ATS_20180511.seq), runs the complete flat pair series
and then switches to the 3s sequencer SeqATS-3-RC14-P2read.seq and executes the same sequence
as with the 2s sequencer, i.e., bias, flat pairs, bias.

The 2s sequencer bias start/end with files 10/19. data set starts/ends with file 20/199, bias frames
start/end with files
200/209.

Flat scan 2 starts with file 210 (time stamp of 7:50pm) and runs the same sequence as Flat scan 1.

Apropos sequencers:

The 3s sequencer does not have both parallels¹s high (fixes the dipole issue) because it doesn¹t work with that configuration but the 3s sequencer does work with a 3s readout which is what was used for the flat scans as mentioned above.

The issue having both parallel phases high with the 3s sequencer has been reported. (An estimate for how long it will take to get this working with the atsWREB is still TBD.).

No data was taken with the modified 2s readout sequencer (both parallel phases high) but a flat series will be taken in the near future to eliminate the ³dipole² effect and to confirm sensor performance.

From Claire today (2018-09-25):

The original 3s sequence file had the issue that no data came out. I made the change to expose (or keep dark) with P1+P2 high, and read out with only P2 high, both for the 3s sequence and a new version of the 2s:

https://github.com/lsst-camera-dh/sequencer-files/blob/master/ATS/ats-3s-rc14-p2read.seq

https://github.com/lsst-camera-dh/sequencer-files/blob/master/ATS/ats-2s-p2read.seq